POWER PLANT ENGINEERING

Established Over 30 Years

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When Cows Throw Monkey Wrenches

—it's time for the engineer to duck and find out why any contented bovine should be lured from green pastures by a mechanico-bolshevik complex. Monkey wrenches have long been regarded the symbol of steam enginers, so for a cow deliberately to hurl one at a hydraulic engineer, killing some of the horses in his turbine, is bordering on professional chaos.

Recently a prominent psycho-analysist, called in on the case, saw nothing unusual in the action of the cow but went raving mad trying to interpret the above picture as a cubist drawing of the cow in the act of hurling the wrench. As a matter of fact the picture shows a dam, one of the murderous kind, that builds up in front of a trash rack and cuts the head right off the turbine

Such a dam led Mr. Carpenter to begin his investigations and enables us to conclude our last night's bedtime story, a famous Mother Goose tale. After considerable difficulty Mr. Carpenter finally succeeded not only in determining the identity of the cow that jumped over the moon, but actually found out where she landed on her return. The cow's name was Katrinka, she threw the monkey wrench in Mr. Carpenter's turbine and he tells about it on page 544.

Power for Detroit's New Masonic Temple

COMBUSTION CONTROL SYSTEM, UNAFLOW ENGINES, UNIQUE CONTACTOR BOARD AND EQUIPMENT PLACED ON FOUR LEVELS ARE FEATURES OF NEW PLANT

TO SATISFY THE VARIED POWER demands of the great new Masonic temple now nearing completion in Detroit, Mich., an interesting power plant has been incorporated in the design. As shown in the view above, the building is an imposing and beautiful work architecturally and every attempt has been made to install equipment in keeping with the high character of the design.

In the power plant, an unusual arrangement of equipment occurs and some of the electrical equipment is entirely different from that ordinarily found in plants of this type. Reference to Fig. 5, a section through the plant, shows the location of equipment on four floors, corresponding to eight floors with their mezzanines in the main building. This arrangement was adopted to avoid spreading the power plant out on one floor and complicating the construction of other parts of the building. In a plan view of the entire building, which cannot be shown here on account of space limitations, the ground area of the power plant appears very small in comparison to the rest of the building. The plant is about 78 ft. long, 66 ft. wide at the engine room and 48 ft. at the boiler room. In addition, on account of the size of the building, a large number of fans, service pumps and heating equipment, to say nothing of a complete refrigeration plant, are installed in fan rooms and pump rooms on the engine room floor level but entirely outside the power plant.

The entire plant, as shown in the illustrations has a most pleasing appearance. The arrangement of equipment is convenient and there is plenty of light and room. Walls of both boiler and engine rooms are attractively finished in brown salt glazed brick. Both boiler and engine room floors are of red tile.

COMBUSTION CONTROL AND CONTACTOR BOARD ARE FEATURES

In the power plant itself are several outstanding features. An interesting arrangement for handling coal and ash is used. The stoker-fired boilers are equipped with combustion control systems, feed-water regulators and all automatic devices possible. Unaflow engines generate power and supply exhaust steam for a vacuum heating system during the heating season. A throw-over to the Detroit Edison Co. service is provided for light loads in summer. A unique installation of a large contactor board is used to handle all the electrical circuits in the building, contactors having been selected for this work instead of circuit breakers.

BUILDING PROVIDES ELABORATE ACCOMMODATIONS FOR MASONIC WORK

Before discussing this equipment in detail, a brief description of the Temple itself will give the reader some idea of the services that the power plant must render. The building has a frontage of 400 ft., a depth of 200 ft. and cubic contents of 11,240,000 cu. ft. It

contains accommodations for 26 Blue Lodges, the Royal Arch Chapters, the Council, the Detroit and Damascus Commanderies, a cathedral seating 1700 with fully equipped stage for the Michigan Sovereign Consistory. Thus the engineering problems in designing the building were complex, since full accommodation had to be provided for the ritual and social necessities of each of the organizations named. The building contains three large banquet halls, with suitable kitchens, capable of handling 5000 people and a beautiful auditorium seating 5000 with stage for grand opera requirements. Three ball rooms, a drill hall, 105 ft. by 156 ft., with locker rooms for 6000 lockers, billiard rooms for 47 tables, swimming pool and showers, 15 bowling alleys and library besides an auditorium seating 800 with stage for third degree work, all incorporated in this building. In addition to all this, one wing of the building is devoted to the Shrine, with a complete club equipment, dormitories and 100 individual sleeping rooms. This great variety of building accommodations must be supplied with electric light, steam heat, ventilation, water service and electric power for various motor-driven devices.

Reference to Fig. 5 shows the layout of the power plant. At El. 106, or approximately 12 ft. above the alley elevation, is the boiler room floor. In this boiler room are installed three Union Iron Works cross-drum, three-pass horizontal water-tube boilers, each with a heating surface of 4200 sq. ft. These are designed for 200 lb. gage maximum working pressure but will operate at 150 lb. Two of the boilers are set together, as shown in Figs. 1 and 3, the third one being set singly across the aisle, with room left for a fourth unit if it ever becomes necessary to install it.

Boiler setting and stokers are designed so that for normal operation boilers can be operated easily at 200 per cent of rating. In this way it is possible with a comparatively small installation to have large steam capacity. Furnaces are each 8 ft. 6 in. wide, 16 ft. 5 in. deep and 11 ft. high to the bottom of the front header. Pre-cast baffles were installed by the boiler manufacturer and carborundum brick is set in the bridge wall and in the side walls at the dump to reduce clinker trouble.

Each boiler is fired by a Riley standard, 4-retort underfeed stoker. These are equipped with moving high side tuyeres and the usual type of reciprocating grate blocks furnished with this stoker. For dumping ash, a rocker plate is provided, as shown in Fig. 5, which may be adjusted for continuous dumping if desired. Each stoker is driven by a 5-hp. 230-v. d.c. motor, installed on the ceiling of the fan room, as shown in Fig. 4, the

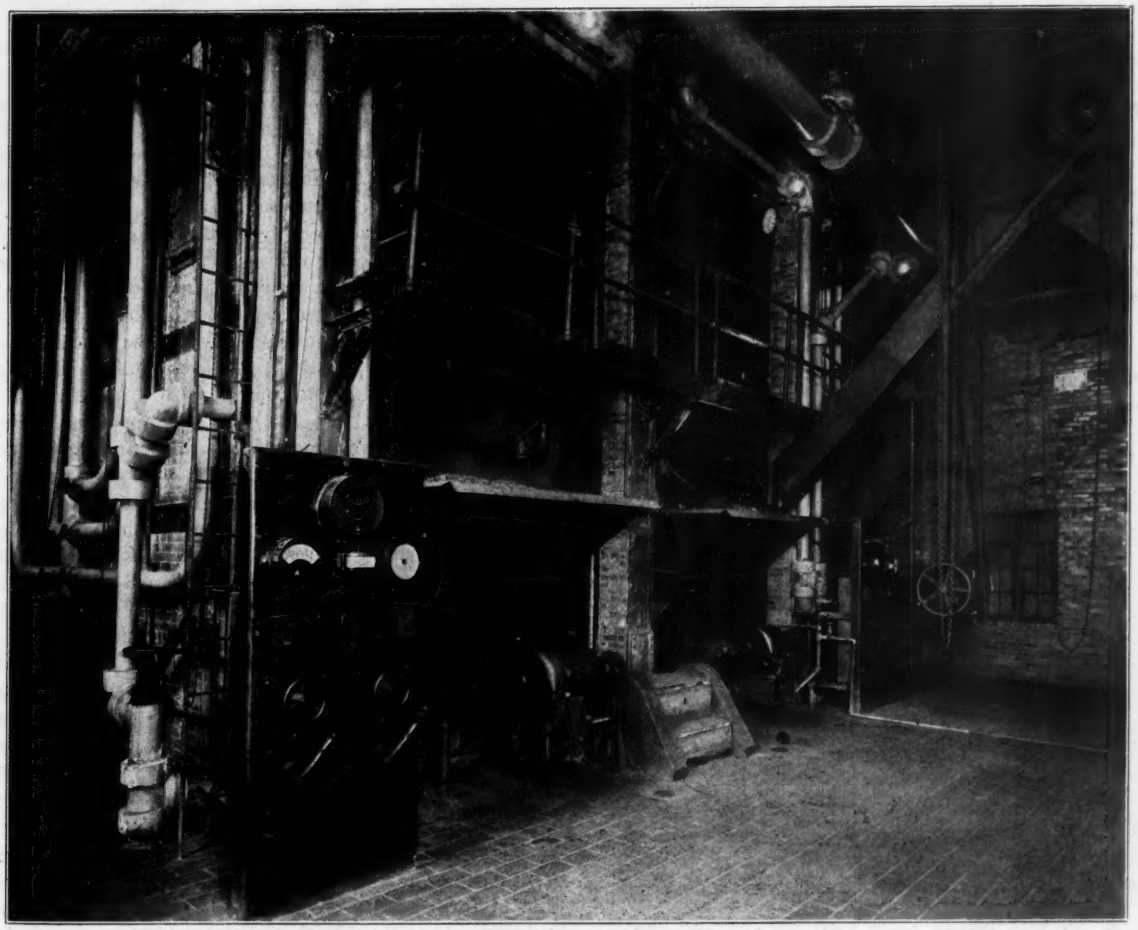


FIG. 1. TWO OF THE THREE STOKER-FIRED WATER TUBE BOILERS, SHOWING COMBUSTION CONTROL PANELS, WEIGH LARRY, SOOT BLOWER CONNECTIONS AND OTHER ACCESSORIES

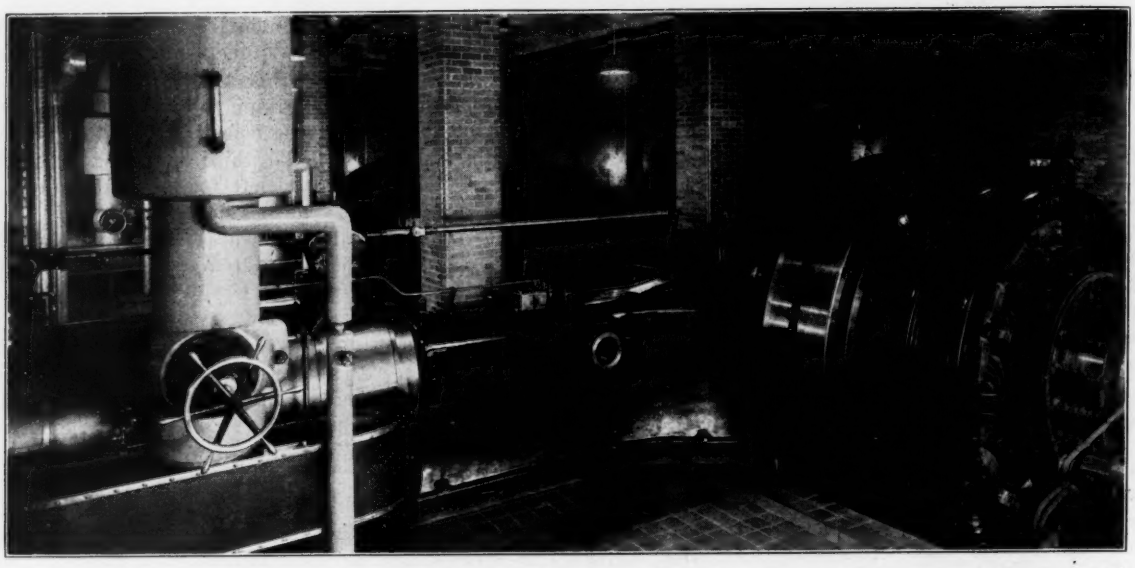


FIG. 2. THREE UNAFLOW ENGINES, ONE OF 200 KW. AND TWO OF 400 KW. CAPACITY OCCUPY THIS ATTRACTIVE AND WELL LIGHTED ENGINE ROOM

chain drive for the stokers running up through the floor; the speed ratio of this stoker drive is 3 to 1. Stoker speed is varied by the combustion control system which will be described later.

Coal and Ash Are Handled Mechanically

These stokers burn West Virginia coal, averaging 14,000 B.t.u. per pound, which is all delivered to the plant by motor truck. The truck comes into the alley at the rear of the building and backs partly into an opening left in the corner of the building, at the elevation shown in Fig. 5 and directly under the ash hopper shown in Fig. 3. The contents of the truck are dumped into a hopper in the upper part of the coal crusher room shown in Fig. 8. This hopper feeds a pan conveyor with a capacity of 40 t. an hr. driven by a 5-hp. d.c. motor running at 1250 r.p.m. The pan conveyor runs through the coal crusher room, which is on the same level as the engine room, and discharges its contents into a gravity discharge bucket elevator, driven at about 75 ft. a minute by a 15 hp. d.c. motor running at 850 r.p.m. This bucket elevator dumps into a 150-t. coal bunker of the suspension type, Fig. 5, of ¼-in. steel plate with a 2-in. lining of gunite concrete. A weigh larry of 1000-lb. capacity delivers coal from the bunker to the stoker hoppers. This larry, shown in Fig. 1, runs along two I-beams under the bunker. It has two fixed spouts, as shown, of just the right length to feed the hoppers on either side. The various gates and the traveling mechanism of the larry are conveniently controlled by hand, the operating chains reaching to the boiler room floor. All the coal handling equipment was furnished by R. H. Beaumont Co.

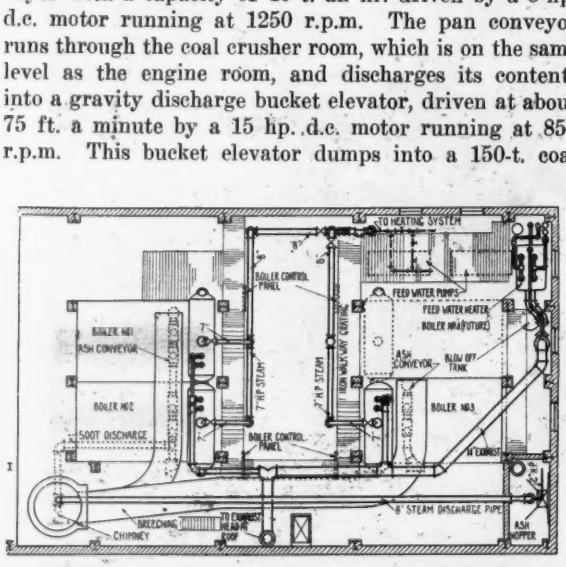


FIG. 3. IN THE BOILER ROOM TWO BOILERS ARE SET TOGETHER AND A THIRD SINGLY, WITH SPACE LEFT FOR A FOURTH IF NEEDED

As explained above, the truck dumping coal into the coal hoppers is in position directly under the ash storage hopper so that, as soon as it is empty of coal, it can take a load of ash from the latter. This provides a convenient method of handling both the coal and ash.

Ash-handling is by the Vasco system furnished by the Vacuum Ash & Soot Conveyor Co. Ash from the stoker dump drops into brick-lined hoppers, as shown in Fig. 5. On the fan room floor level, running just in front of each hopper are 8-in. pipes, with suitable loading ports. These pipes connect with the main conveyor pipe leading up to the ash hopper, which has a capacity of 15 t. A vacuum is created in this tank by a special steam jet fitting, exhausting through an 8-in. pipe into the chimney. When ash is raked out of the hoppers into the pipe openings, the air rushing in to fill the vacuum in the hopper carries the ash along with it. All ash is conveyed dry and this makes it convenient to run a 6-in. soot line from the base of the chimney to the conveyor pipe at No. 2 boiler, so that the chimney can be thoroughly cleaned when necessary. No steam jets are used in this system, except the one which creates a partial vacuum in the ash hopper.

The chimney, erected by the Alphons Custodis Chimney Co., is of face brick above the roof line, with stone trim to form a part of the architectural design of the building. It is lined with radial brick, the part of the chimney inside the building consisting only of this lining. The bottom of the chimney is at elevation 126, or

FIG. 4. FORCED DRAFT FOR EACH STOKER IS SUPPLIED BY A 13,000-C.F.M. MOTOR-DRIVEN FAN, SPEED BEING REGULATED BY COMBUSTION CONTROL SYSTEM. STOKER DRIVE MOTORS APPEAR ABOVE ON THE CEILING

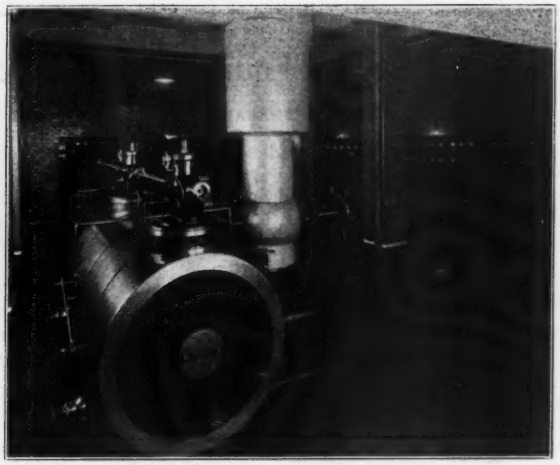


FIG. 6. CLOSE-UP OF ENGINE NO. 3 SHOWING DOUBLE-BEAT POPPET VALVE GEAR. CONTROL BOARD FOR CONTACTOR PANELS IS MOUNTED AT THE RIGHT

about that of the boiler drums; it is 172 ft. high and 7 ft. in diameter inside.

Forced draft for the stokers is supplied by American Blower Co. fans, installed in the fan room as shown in Figs. 4 and 5. Each fan has a capacity of 13,000 cu. ft. a minute at a water pressure of 5½ in. and is designed for boiler operation at 250 per cent of rating. It is driven by a 20 hp., d.c., 230-v. motor with a speed of 1100 r.p.m. at maximum load. This speed is varied by the combustion control system, which will be described later.

Make-up for boiler feed comes from building hot water system, where it is deaerated.

Feed water is supplied to the boilers by two 14 by 8 by 16-in. Burnham outside center-packed plunger pumps, installed on the boiler room floor behind No. 4 boiler space, as shown on Fig. 3. City water is used without chemical treatment for make-up water. All the returns from the building heating system will be used and the necessary make-up water will come from the Elliott deaerators for the building hot water system, being drawn as needed into the feed water heater. Feed water is heated to 210 deg. by a Cochrane open type feed water heater, of 75,000 lb. an hour capacity, installed on a gallery above the feed pumps, as shown in Fig. 3. Steam for this heater is taken from the low pressure engine exhaust line. Emergency feed water connections are also made to the swimming pool above the boiler room and to a large house service tank on the roof.

Feed water level in the boilers is controlled by Copes feed water regulators, the feed water piping being in a loop with the regulators by-passed. Wright-Austin water alarm columns are provided on the boilers. Connections for the Diamond soot blowers, of which there are 5 units on each boiler, are shown in Fig. 1 on No. 2 boiler. Two blowoff connections, using Yarway seatless blowoff valves, are on each boiler. Boilers are blown into the blowoff tank located on the fan room floor below the feed water heater.

The combustion control system installed at this plant by the Benjamin Engineering Co. is one of the most interesting features. It consists of apparatus for controlling the products of combustion, accomplished by regulating the stoker and fan speeds and damper positions so as to proportion the quantity of fuel and air supplied to each boiler to give the best possible combustion efficiency of the group of boilers at all ratings.

Fan and stoker motors are of the adjustable-speed, d.c. type, so calibrated that with equal voltages impressed upon their shunt fields, their speeds will be within ½ of 1 per cent of each other. The shunt fields

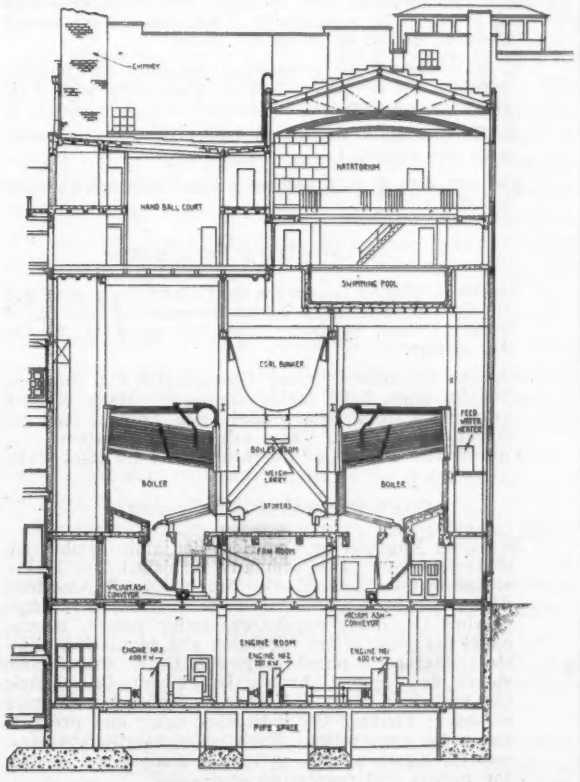


FIG. 5. SECTION THROUGH POWER PLANT SHOWING UNUSUAL ARRANGEMENT OF EQUIPMENT ON FOUR LEVELS, WITH BOILERS AT TOP

Principal Equipment in Detroit Masonic Temple Power Plant

General

Location...Temple Ave. and Second Blvd., Detroit, Mich.
Size of Building.....
...400 ft. long, 200 ft. deep, 11,240,000 cu. ft. contents
Size of Power Plant—88 ft. 6 in. high, 77 ft. 4 in. long, 66 ft. wide on engine room level, 48 ft. wide at boiler room level.
Building Contractor.....H. G. Christman Co.
Piping Contractor.....Pittelkow Heating & Eng. Co.
Electrical Contractor.....McCleary Harmon Co.
Architects and Engineers.....Geo. D. Mason & Co.

Boilers, Furnaces and Stokers

3 Union Iron Works Cross drum boilers, each with 4200 sq. ft. heating surface. Designed for 200 lb. working pressure, operated at 150 lb.

3 Furnaces, 1 single setting and one double setting. Single setting, inside dimensions 16 ft. 5 in. deep 11 ft. high to bottom of front header and 8 ft. 6 in. wide. Double setting same length and height, each furnace 8 ft. 6 in. wide inside.

3 Riley-Stoker Corp. 4-retort Standard Underfeed stokers, with setting designed to operate boilers normally at 200 per cent of rating. Driven by 5 hp., 230-v., adjustable speed General Electric Co. d.c. motors.

15 units Diamond Power Specialty Corp. Soot blowers, 5 units per boiler.

3 Northern Equipment Co. Copes boiler feed water level regulators.

Coal and Ash Handling Equipment

Coal Conveying Equipment furnished by R. H. Beaumont Co. capacity 40 t. an hour. Pan conveyor driven at about 90 ft. a minute by 5 hp., d.c. motor; bucket elevator, driven by 15 hp. d.c. motor.

1 R. H. Beaumont Co. suspension type steel coal bunker, capacity 150 t. Made of ¼-in. plate lined with 2 in. of gunite concrete.

1 R. H. Beaumont Co. weigh larry, 1000 lb. capacity, with two spouts.

1 Vacuum Ash & Soot Conveyor Co. Vasco ash removal system.

Fans and Draft Equipment

3 American Blower Co. forced draft fans, each of 13,000 cu. ft. per min. capacity at pressure of 5½ in. of water. Driven by 20-hp., variable speed G. E. Co. d.c. motors.

1 Alphons Custodis Chimney Construction Co. chimney, 172 ft. high, 7 ft. inside diameter. Made of face brick with stone trim, radial brick lining. Soot removal connection to Vasco ash handling system.
Parker Rust-Proof Co. breechings of ⅜-in. steel plate.

Combustion Control System

1 Benjamin Engineering Co., Hess-Benjamin combustion control system. This company furnished 3 G. E. Co. stoker motors, 3 G. E. Co. fan motors, 3 American Blower Co. fans, as described above. Benjamin Engineering Co. draft regulators, boiler panels, master panel carrying steam regulator and regulating rheostat; engineer's panel carries a G. E. Co. electric steam flow meter; Brown Instrument Co. electric Co_2 recorder; Leeds & Northrup electric temperature recorder; Foxboro Co. indicating draft and pressure gages for each boiler. Each boiler carries the same meters, together with switching and control devices for motors and regulating equipment.

1 Motor-generator exciter set for control equipment.

Boiler Feed Pumps and Feed Water Heaters

2 Union Steam Pump Co. Burnham outside center packed plunger pumps, each 14 in. by 8 in. by 16 in.

1 Cochrane Corp. open type feed-water heater, capacity 75,000 lb. per hr.

Steam Engines and Generators

3 Ridgway Dynamo & Engine Co. unaflow engines, each driving a 250-v., d.c. self-excited Ridgway generator, direct-connected. Two units rated at 400 kw. at 150 r.p.m., one unit rated at 200 kw. at 200 r.p.m. at 150 lb. throttle pressure.

Miscellaneous Mechanical Equipment

Stop and check valves and 14-in. atmospheric relief valve.....Scott Valve Mfg. Co.
Yarway blowoff valves.....Yarnall-Waring Co.
Safety valves, two 3½-in. per boiler.....Scott Valve Mfg. Co.
Water columns .....Wright-Austin Co.
Steam traps .....Wright-Austin Co.
Republic high-pressure piping Van Stone joints above 3½ in., electrically welded flanges, 3½ in. and below.
High-pressure pipe insulation, 85 per cent magnesia .....S. H. Morgan Co.
Steam gages....American Schaeffer & Budenberg Co.
Pump governors... .....Fisher Governor Co.

1 Venturi meter.....Builders Iron Foundry
Air compressors, 1 steam-driven and 1 motor-driven .....Chicago Pneumatic Tool Co.
Walkways and gratings..Detroit Steel & Conveyor Co.

1 Dayton-Dowd Co. centrifugal fire pump. Fire pump, capacity 1000 g.p.m. against 150 lb. head, driven by 175-hp. motor.
Separators on main and exhaust steam lines..Poe Co.
Oil filters.....S. F. Bowser & Co., Inc.

Service Pumps in Pump Rooms

Jennings Hytor vacuum pumps on heating system.... .....Nash Engineering Co.

Service pumps supplied by Union Steam Pump Co. as follows:

2 Three-stage motor-driven centrifugal house service pumps, 2-in. size, 125 g.p.m., each against 227 ft. head, 1800 r.p.m.

2 Single-stage, 2-in. motor-driven centrifugal swimming pool pumps, 100 g.p.m., each against 70 ft. net head, 1700 r.p.m.

2 Single-stage 1¼-in. motor-driven centrifugal drinking water pumps, 30 g.p.m., each against 60 ft. head, 1700 r.p.m.

1 Five-stage, 2-in. motor-driven centrifugal sprinkler tank filler pump, 40 g.p.m. against 370 ft. head, 1800 r.p.m.

2 Duplex piston hot-water circulating pumps, each 9 by 6 by 12 in., bronze fitted.

Electrical Equipment

1 Control board, 10-panel, carrying meters, control switches and indicating lamps...General Electric Co.

1 Contactor board, carrying contactors used as circuit-breakers to handle power and lighting circuits..... .....General Electric Co.

Storage battery for low voltage system, signals, radio, bells.....Electric Storage Battery Co.

Electric equipment of buildings includes automatic telephones, watchman's service, clocks, cab call, Gamewell fire alarm system, public address system, etc.

of the stoker motors are connected to a common exciter and the shunt fields of the fan motors are connected to a common exciter. The voltages of these two exciters, which are driven by a constant speed motor and are located on fan room floor are controlled by a regulating rheostat, which is in turn controlled by a steam regulator connected to the steam manifold. Any change in steam pressure will cause the regulating rheostat to readjust the voltages of the two exciters and thus change the speed of the fan and stoker motors and thereby readjust simultaneously on each boiler the quantity of fuel and air supplied to the group of boilers. This readjustment is about 10 per cent. The motors are also provided with means for manual operation so that any boiler or any individual fan or stoker may be operated entirely manually if the operator should so desire.

A complete system of boiler meters mounted on panels as shown in Fig. 1 is provided for each individual boiler so that the operating characteristics and efficiencies of each boiler may be easily checked. There is also provided an engineer's panel, installed outside the engineer's office on the engine room floor, as shown in Fig. 7, upon which is mounted steam flow meters, CO_2 recorders, temperature recorders and pressure gages, so that the chief engineer has at all times an indication of what is going on in the boiler room.

Each boiler is provided with a damper regulator operated from furnace pressure set to hold any desired draft over the fire. By means of a push button mounted in each individual boiler panel, this draft may be controlled manually if desired. Steam regulator and regulating rheostat are mounted on the master panel, installed on the boiler room floor.

For each boiler there are two field transfer switches for changing the fan and stoker motors from manual to automatic control and two rheostats for regulating the speed of the fan and stoker motors through their entire speed range when on manual control and through 10 per cent of their speed range when on automatic control.

Piping Arrangements

Reference to Figs. 3 and 8 gives an idea of the piping arrangements. High pressure steam lines run from the boilers to a 10-in. riser leading to the engine room, whence suitable connections are led through steam separators to the engines. Engines exhaust into a 14-in. riser, leading up through the engine room into the boiler room, where a connection is taken off to the feed water heater. This 14-in. pipe then runs across the upper part of the boiler room, as shown, to a 16-in. riser leading to the roof, this riser being equipped with a Poe Co. exhaust head. Each boiler has two 3½-in. safety valves, the discharges of which are piped into the 14-in. exhaust pipe so that they can discharge above the roof. A Scott atmospheric relief valve is provided for relieving the feed water heater into the exhaust riser.

In the boiler room a 6-in. high pressure steam line is taken off the 10-in. riser to the engines; this 6-in. line is tapped for connections to the boiler feed pumps and then drops to the engine room floor and runs into the adjoining pump room through suitable reducing valves, for connection to the heating system. In the engine room, the 14-in. exhaust riser is tapped for a 14-in. connection running into the pump room to supply exhaust steam to the heating system.

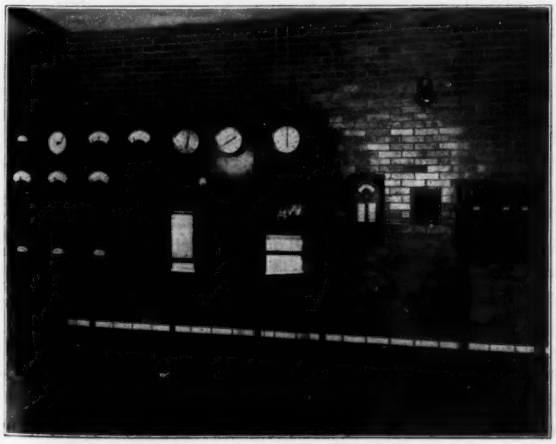


FIG. 7. ENGINEER'S BOARD ON ENGINE ROOM FLOOR, CARRIES FULL EQUIPMENT OF METERS AND GAGES. SMALL BOARD CONTROLS HEATING AND VENTILATING MOTORS

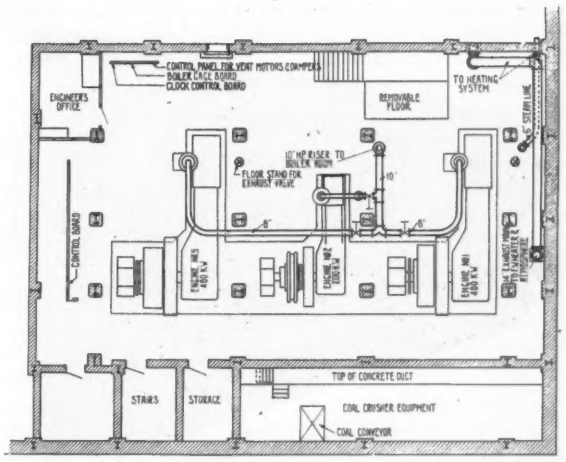


FIG. 8. PLAN OF ENGINE ROOM, SHOWING THREE UNAFLOW UNITS AND POSITION OF CONTROL BOARDS

Three Unaflow Engines Drive D.C. Generators

In the engine room are installed three Ridgway Unaflow engines driving 250-v. d.c. three-wire self-excited Ridgway generators. Two of these units are rated at 400 kw. at 150 r.p.m. and the third at 200 kw. at 200 r.p.m. Steam pressure at the throttle is 150 lb. gage. These engines have steam valves of the double-beat poppet type, actuated from a single eccentric.

The cylinders are equipped with spring loaded automatic relief valves, so that when exhaust is being supplied to the heating system, they are operating with a slight vacuum and if this is lost the relief valve functions to prevent excess pressure until the clearance valve can be opened by hand. Lubrication is by both the splash system and the force feed system, the latter being obtained by a pump in the crankcase.

For controlling electrical circuits, a unique arrangement of contactors, used instead of circuit breakers, is employed. Figures 9 and 10 show portions of the control board installed in the engine room and of the contactor boards in the room below.

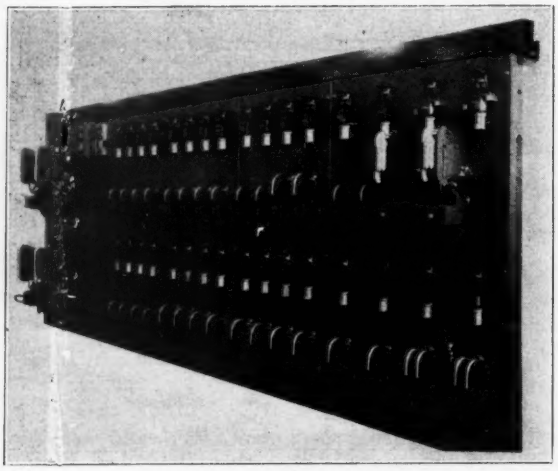


FIG. 9. LEFT-HAND SECTION OF DISTRIBUTION CONTACTOR BOARD THAT HANDLES ELECTRICAL CIRCUITS THROUGHOUT BUILDING

The remote control system is of especial interest because this building is one of the first plants to use contactors, or electromagnetic switches, for the control of generator and feeder circuits, these contactors being of a type formerly used for the control of motor circuits, large or small, and bearing the G.E. designation CR-2800.

Each generator has an individual control panel, Fig. 10, located on the floor below. Leads from the generator run from beneath the machine through a short tunnel to this control panel, and thence to a set of five bus-bars used for paralleling the three machines. Contactors are used to open or close the circuits in the positive and negative mains, the positive and negative equalizer leads and the neutral line. As the two-hour overload current rating of the 400-kw. machines is about 2100 amp., two 1500-amp. contactors are used in parallel for controlling the main positive or negative circuits. Six hundred ampere contactors are used for making the equalizer connections, and one 300-amp. contactor for the neutral circuit. For the 200-kw. machine, one 1500-amp. contactor is used for each of the main leads, a 300-amp. contactor for the equalizer, and a 150-amp. contactor for the neutral circuit.

Protective and Interlocking Devices

The equalizer and main line contactors provide under-voltage protection by dropping out on failure of power, not closing again on the return of power unless closed by means of the push and pull switches on the control panels. The neutral contactor will open on failure of voltage and will again close upon restoration of power. The main line and equalizer contactors are so electrically interlocked that the equalizer contactors must be closed before the line contactors can be closed. A time delay, electrical reset, overload relay and a reverse current relay are located in the positive and the negative main line circuits. Inverse time limit relays are used throughout, due to the character of the load. The starting of a large motor or the simultaneous lighting of a quantity lamps will cause a momentary inrush of current which would trip an instantaneous overload relay, while an inverse time limit relay will not trip unless the overload persists long enough to overheat the generator or endanger the lines. All relays are set to trip at approximately 200 per cent load in 20 seconds. A higher overload would naturally cause a relay to trip in less time, and a lower overload in a longer time. On short circuits the action is practically instantaneous.

Generator bus bars are connected to the bus bars behind the distribution board, located on the same floor as the generator panels and directly beneath the control board, Fig. 6, from which all circuits, including the generator circuits, are controlled. This distribution board, part of which is shown in Fig. 9, controls the various feeder circuits which are all brought in at one end of the board and connected through their respective inverse time limit overload relays and contactors to either the main or emergency bus bars. This arrangement, a greatly simplified construction, saved cable, busses and considerable valuable space.

There are 16 main lighting circuits of from 40 to 1000 amp. capacity, 8 emergency lighting circuits varying from 40 to 220 amp., 12 main power circuits running from 150 to 1000 amp., and 8 emergency power circuits of capacities from 150 to 500 amp. The branch lighting circuits are two wire balanced on three-wire mains, and the power circuits are two-wire.

Two of the power feeders supply the electric ranges, ovens and broilers in the two kitchens.

The emergency bus receives its supply from the station bus at all times when there is voltage on the station bus. If voltage should fail on the station bus because of a shut-down of the generators, an overload or short circuit on the station bus, the emergency bus receives its supply from the Detroit Edison Co. automatically by means of throw-over contactors. However, in case of a short circuit or a severe overload on the emergency bus sufficient to open the generator protective devices, the Edison service is not connected automatically but can be connected by using the remote control switch on the control board. If the trouble still persists, the overload relays will again trip and the emergency bus will remain disconnected until the source of trouble is removed.

Another rather unusual feature of this installation is the use of interlocks to insert resistance into the coil circuit after the contactor has been closed. The contactors are sequenced in the same manner as on the generator panels, the first one to close being in the positive circuit, and the second in the negative circuit. This interlock is placed on the negative line contactor; thus, after it closes, the resistance is in series with the coils of the two contactors and the current for holding the contactors closed is thereby cut down to a minimum. When the contactor is open this resistance is short circuited by the interlock and the full voltage can then be impressed on the coils for closing the contactors.

Control Board

The control board consists of ten panels of black, marine finish slate, mounting edgewise-type ammeters and voltmeters on the generator panels, which also contain the usual equipment for controlling the voltage of each machine. In addition, twin-pull control switches with indicating lamps are mounted on the middle sections of the panels for operating the main generator contactors and emergency transfer contactors.

Feeder panels are equipped with recording watthour meters of the mercury type. Similar twin-pull switches and indicating lamps are mounted on the feeder panels, each of which operates a pair of contactors controlling some main feeder. This design of control board permits of the use of low potential, as nothing exceeding 125 v. is on the board. The wattmeters for recording the generator power are of the General Electric HSV-7 type, the shunts for these being located some distance away at the generators. Distant dial mechanisms are included for operating these meters. No soldered joints are used in making any of the main and feeder bus connections; these are all joined by means of Dossert connectors.

The entire switchboard was installed by McCleary Harmon Co. electrical contractors. All the electrical

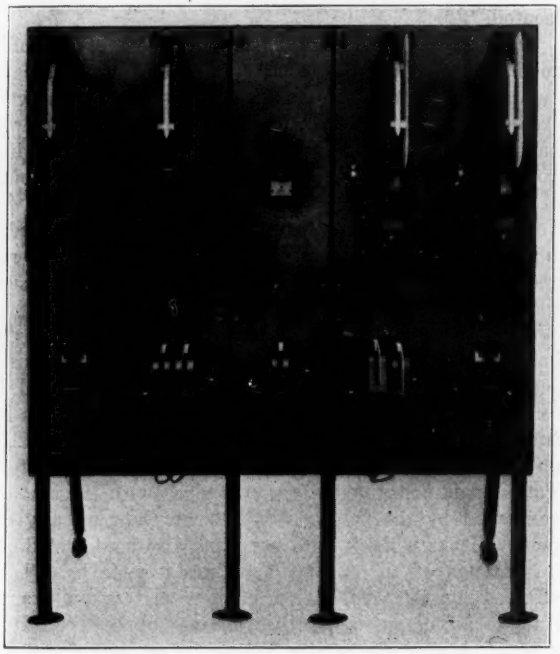


FIG. 10. GENERATOR LEADS RUN DIRECTLY TO CONTROL PANELS OF THIS TYPE, ON WHICH CONTACTORS CONTROL THE CIRCUITS TO THE BUS BARS AND THENCE TO CONTACTOR PANELS

switching and protective equipment on this board was furnished by the General Electric Co. The heating, ventilating and pumping services in the building are operated by General Electric motors with remote magnetic control.

Variety of Equipment for Heating, Ventilating and Refrigerating Service

For the heating of the building, a vacuum return system is used, taking exhaust from the engines, adding live steam make-up in extremely cold weather. This live steam pressure will be reduced twice, once to 50 lb. for kitchen service and then down to the heating pressure which will be from 2 to 3 lb. gage. The heating and ventilating equipment is all part of one system; 28,000 sq. ft. of direct radiation are installed and 22,000 sq. ft. of blast coils. Air filters are installed and 23 supply equipments put air into the building. In 18 different fan rooms are installed 63 supply and exhaust fans for the various parts of this system.

Complete refrigeration service for kitchens, drinking water lines and other building services will be supplied by two 35-t. ice machines. The domestic hot-water supply, from which boiler feed make-up water is drawn as explained above, will be deaerated to reduce corrosion.

Air compressors with a capacity of 250 cu. ft. a minute are installed to provide air for sewage ejectors, door operators, temperature regulating system, for blowing out motors and other services.

At the time the building was being designed, the Detroit Edison Co. could not supply steam for heating. Careful calculations were made investigating the cost of generating power and steam for heating from a local plant such as installed compared with a simple heating plant and purchased power.

Results indicated a considerable saving annually by installing a generating plant. One of the factors affecting the saving was the fact that direct current was needed for the slow speed ventilating fans, which are direct connected to the motors. Generated power is used at 110/220 v. as produced, without transformation.

The Masonic Temple power plant was designed under the supervision of George Wagschal, consulting engineer for the firm of Geo. D. Mason & Co., which was in charge of architectural and engineering design of the entire building. Alfred Cant is chief operating engineer of the plant, under the supervision of Frank E. Fisher, secretary of the Masonic Temple Asso. We are indebted to Mr. Wagschal and to T. Harvey of the General Electric Co., Detroit, for data and assistance in preparing this article.

In the 150,000-kw. steam electric generating station of one of the large Western power companies, some interesting experiments are being carried on in an effort to eliminate the electrolytic corrosion of condenser tubes. Tests were made which determined the existing electromotive force or difference of potential between the admiralty metal condenser tubes and the sea water used for condenser cooling purposes under normal conditions of machine loading and temperatures for various cooling water temperatures. A small motor-generator set was then installed by means of which a source of variable d.c. voltage was made available. Connections were then made between this motor-generator set the condenser tubes and the cooling water in such a manner that the counter e.m.f. of the set exactly neutralized that of the galvanic action of the condenser. Sufficient time has not yet elapsed since the installation of the apparatus for any definite result of the experiment to be noted. It has, however, now been in operation for a period of some six months and so far no leaks have developed in the condenser tubes under test.

Air intake pipes on compressors should be the full diameter of the opening on the air cylinder and should increase 1 in. in diameter for each 8 ft. in length. The pipe should run to the outside of the engine room and be located so as to take air from a considerable height above the ground. The screen used should have a free area of at least four times that of the pipe and should be easily removable for cleaning.

Modern Practice in Steam Flow Measurement

STEAM FLOW METER SOLVES ENGINEERING PROBLEMS OF ECONOMIC IMPORTANCE. BY MILTON A. GOETZ*

ACCURATE measurement of steam and the development of the flow meter for extensive commercial use is one of the achievements of the last decade. Although the fundamental laws governing the flow of liquids through pipes were discovered over a hundred years ago, it was only recently that this knowledge was applied to the measurement of steam. With the great advances that have been made in power plant engineering the steam flow meter has come into almost universal use.

Steam generation is one of the prominent engineering sciences and in no other field is the possibility of still further improvement so great. Turbine and generator efficiencies have now reached a point where improvements come slowly and, it is evident, that further research in the boiler room will be a productive field for economy.

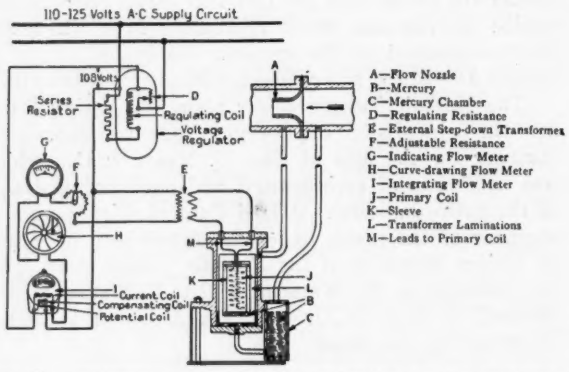


FIG. 1. SHOWING A SCHEMATIC DIAGRAM OF AN ELECTRICALLY OPERATED FLOW METER INSTALLATION

The first place then for the steam flow meter is on each boiler outlet. With coal cost amounting to well over half the total power plant expense, it is essential that the boilers be operated efficiently and that no steam be wasted. In the power house the voltmeter and watt meter have become as much a part of the switchboard equipment as the panels upon which they are mounted, and no engineer would consider operating the machines without them. In the boiler room, the pressure gage and flow meter are equally essential for intelligent operation, without them the fireman is working in the dark.

All boilers, regardless of type, become dirty after continuous operation. The scale from within and soot from without gradually collect and build up until the transfer of heat from the fuel to the water is cut down and efficient operation is no longer possible. Results show that a clean boiler will generate from 30 to 50 per cent more steam, for a given amount of coal, than will one that has been on the line for considerable time without proper cleaning and attention. The amount of fuel burned is in each case the same, yet the pounds of steam generated are different. It is expensive to take a boiler off the line and clean it. The problem, then, becomes one of balancing the inconvenience and expense of cleaning, against the added fuel expense. It is evident that these factors cannot be determined with accuracy unless flow meters are installed on each boiler.

FLOW METERS INDICATE POOR OPERATION OR COMBUSTION

When installed on a battery of boilers, the flow meter will also show if any of the boilers are "loafing or if one is being pushed too hard. Holes in the fire, leaky settings which admit excess air, foaming or priming, burned-out baffles, incorrect draft, or poor feed water regulation will result in decreased evaporation for the same fuel fired and the flow meter will show the necessity of an investigation until the source of trouble is located.

But of what good is efficient operation in the boiler room, if steam is subsequently wasted in other departments? Even with the maximum amount of steam generated per pound of coal, the efforts of the fireman will have been of no avail if others further along the line do not exercise economy and watchfulness. The amount of steam to turbines, engines, pumps, processes in industrial plants, and for heating, is necessary knowledge for power plant operation. It is not only considered good business, but good engineering as well, to measure the steam where it is used.

In large industrial plants where the steam from one boiler house goes to many buildings, the amount used for each different process is measured and figured in as a part of the cost of the ultimate product. This insures that all departments will use steam economically, and is the basis of the boiler house accounting system. Total steam consumed, when compared with the amount generated by the boilers will at once show up any expensive leaks which would not otherwise be detected.

Savings of thousands of dollars a year have been effected by the installation of flow meters on branch lines to auxiliaries and manufacturing processes. It is a rare instance where flow meters do not pay for themselves the first year. Many times when it is thought necessary to purchase additional boilers to carry the load, the installation of a steam metering system will render this expenditure unnecessary.

Foremen and workmen cannot easily be made to consider the steam that they use in terms of the coal pile. A flow meter assists in translating steam consumption into terms which are not only visible but graphic. The facts become available, and interest and economy follow.

CORRECT DISTRIBUTION OF COSTS IS IMPORTANT FOR ACCOUNTING PURPOSES

It might further be said that no industrial plant, however small, should attempt to run its power plant without flow meters on their boilers and without measuring the steam used in the different departments so that an analysis of operating costs may be made. In the end, the flow meters may show that it is cheaper to buy power on the outside. By so doing, they of course eliminate their own use, nevertheless they are good business for the industrial plant in the long run.

Before taking up typical installations, a brief description of the flow meter itself may be interesting.

*Flow meter specialist, New York Office, General Electric Co.

There are two distinct parts to each unit; the differential pressure producing device which is inserted in the pipe line, and the meter body and registering features.

The pitot tube, the forerunner of modern steam differential devices, is now ordinarily used only for testing purposes. For permanent installation there are three types of differential pressure producing devices, the Venturi tube, and flow nozzle, and the orifice plate. The former is used more on water and gas lines, so that in the measurement of steam the flow nozzle and orifice plate are in most general use.

The design of the meter and registering equipment is very simple. Practically all types consist of a U-tube of mercury in some form or another.

Assuming for illustration that the flow of steam at 150 lb. gage is to be measured, a restriction such as a flow nozzle would be installed between two of the flanges in the pipe line. The steam, in order to get through this restricted section must increase its velocity. In so doing, there is a temporary drop in pressure. In other words, under the throat of the flow nozzle the pressure will be less than 150 lb., the amount of the difference depending upon the rate of flow. By connecting one leg of the mercury U-tube to a point ahead of the nozzle, and the other leg to a point underneath

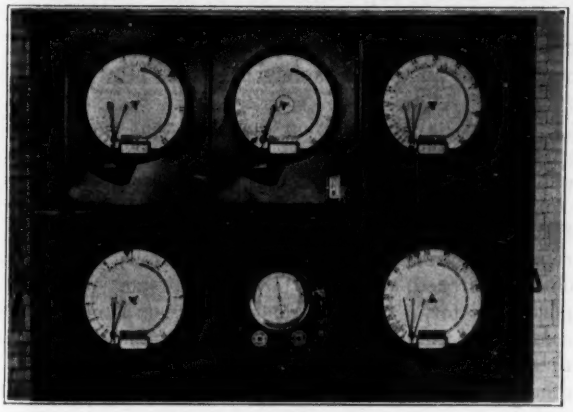


FIG. 2. COMPLETE PANEL BOARD INSTALLED IN A CENTRAL STEAM HEATING SYSTEM STATION

the throat, it is at once apparent that the difference in pressure will force the mercury down on one side of the U-tube and up on the other until the column of mercury thus supported balances the differential pressure. This is the flow meter in its most simple form and is known as a manometer.

In the mechanically operated indicating, recording, and registering flow meters, the meter body is still a U-tube of mercury. A float rests on the surface of the mercury in one of the legs, and its rise and fall is transmitted mechanically to the indicating, recording and registering features.

The electrically operated flow meter body is also a U-tube of mercury. In this type of meter the column of mercury, that is supported by the differential pressure, forms part of an electrical circuit. The higher the mercury rises, the less will be the resistance of the circuit, and the greater the amount of current that will flow. Electrical instruments placed in this circuit will read the amount of current, or better still, can be calibrated to read direct in terms of pounds of steam per hour or boiler horse power. Figure 1 represents a diagrammatic view of the complete layout of an electrically operated flow meter. The same meters that are used in the measurement of steam may also be used in the measurement of water, air, or gas. The only difference is that the flow nozzles are made of bronze instead of steel, and the equipment is calibrated for steam, water, gas, or air as the case may be. Typical installations may serve to clarify the points discussed above.

The photograph in Fig. 2 shows four indicating, recording and registering mechanically operated flow meters, with recording temperature and pressure gages. These meters, installed on a municipal steam heating

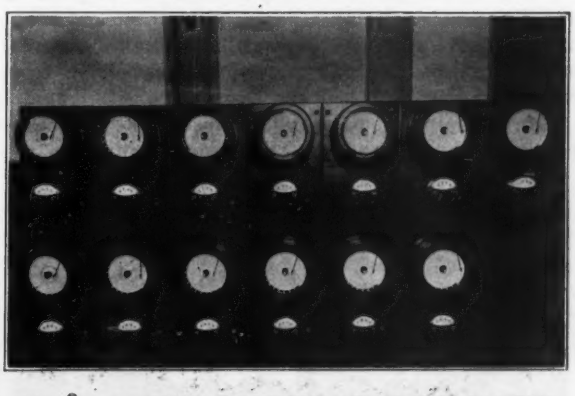


FIG. 3. A TYPICAL INDUSTRIAL PLANT INSTALLATION

system, measure the steam bled for district steam heating and industrial purposes. On each chart there is a record, not only of the flow of steam, but of the temperature and pressure as well. The fifth flow meter at the top center is a live steam meter operating in conjunction with a special control located in the center of the panel. When the bled steam pressure goes below a predetermined point the control cuts in live steam, thus maintaining the required pressure. These five flow meters tell the complete story; for at all times the operators know what kind of steam is being used, where it is going, and the exact number of heat units that it contains.

Instruments for Entire Plant May Be Grouped Together

Figure 3 shows a group installation of 13 electrically operated flow meters located in a textile mill. Five of them measure the steam output from the boilers, and remaining ones measure steam to various parts of the mill. On the front of each boiler is a large indicator which serves as a guide to the fireman in operating his boilers. Two of the boiler room indicators are illustrated in Fig. 4.

In this particular case the electrical scheme worked out very nicely, for it made possible the location of all of the recording and totalizing instruments in the superintendent's office. From this one point the generation, distribution, and use of the steam can be watched.

The meter bodies and flow nozzles were scattered throughout the plant, some of them being located in tunnels underneath the street; and it was only by virtue of the electrical method of transmitting readings

that the instruments could all be located at one central point.

Another interesting installation, illustrating the flexibility of the electrical layout, was recently made in a large industrial power plant in the middle west. There were six boilers, each with double outlet. Two indicating instruments, one for each outlet, were placed on the front of the boiler. In the meter room there were two corresponding curve drawing instruments. In order to know the total amount of steam passing through both outlets, the two electrical circuits were joined together, and one double capacity integrator added up the total steam generated by the boiler.

As an example of how the flow meter may be used to advantage in process work, there is the problem of distilling crude oil. In cracking the oil, steam is admitted to the still, not necessarily at a uniform rate, but according to a predetermined cycle found by experience to be most efficient and economical.

In the pulp and paper mill industry, the flow, temperature, and pressure of the steam admitted to the

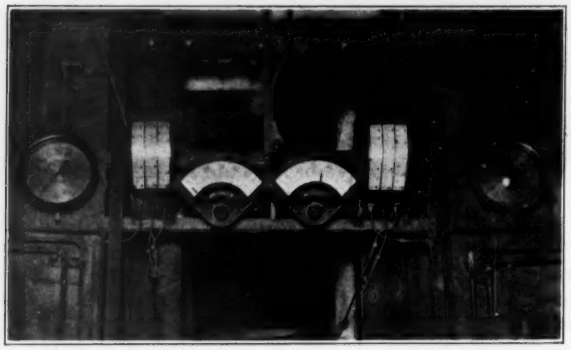


FIG. 4. THE STEAM INDICATOR IS TAKING ITS PLACE WITH PRESSURE AND DRAFT GAGES ON BOILER FRONTS

digesters are of vital importance. Here again it is a question of experimenting to find out when and how much steam should be used to make the best grade of paper. Once the ideal cook is determined, the flow meter will make possible the duplication of this cook thus insuring a pulp of uniform quality. Any number of such examples could be given.

The flow meter today is being used for the measurement of steam at high pressures ranging up to 900 pounds gage, and on low pressure heating and process lines where the total pressure does not exceed 4 or 5 pounds.

In the measurement of high pressure steam there is, of course, the matter of safety to consider; and in some plants it is considered better practice to measure the water input to each boiler rather than the steam output. By the same reasoning, the condensate from the pumps and turbines is measured to obtain the rate of consumption.

Piping Layout Should Be Given Consideration

The statement has often been made that wherever there is steam passing through a pipe line, a meter can be installed for measuring the flow. In general this is true, although it may sometimes be necessary to revise the piping arrangement. Elbows, tees, globe valves and there should be at least six pipe diameters of straight run preceding, and three pipe diameters of straight run following, the differential pressure producing device. In the design of a power plant today this fact is generally taken into consideration when the plans are drawn up, and the piping arrangement is laid out so that flow meters can be properly installed.

Variations in the rate of flow have no effect on the accuracy of the flow meter as it is designed to take care of fluctuations and changes. Difficulty, however, is encountered in the measurement of steam to reciprocating units. Here the flow changes rapidly from maximum to zero many times a minute, and the mercury in the meter body is not able to follow quickly enough. In such instances the meter will read high. No altogether practical solution, fitting all cases, has been developed for this condition.

In process work such as previously illustrated where the amount of steam used is regulated through a valve, the meter should be connected on the high pressure side of the valve toward the boiler. Should the meter be connected beyond the valve, the pressure will vary and the meter will not be accurate. There might even be times when there would be a vacuum on the meter body.

To install meters on the boilers and branch lines may look like a large expenditure at one time; but it invariably pays to know how much steam each boiler is generating and where this steam is going. Only in this way can an answer to the eternal question of waste be found.

Present day competition demands that the finished product be manufactured as efficiently as possible. No effort is spared to improve the process or to secure new equipment that will reduce the cost of manufacture. Because the production of a manufactured commodity represents something tangible and can be seen, it is closely watched, while the power plant, an equally important factor, is often overlooked. Steam is not a mere commodity. It is an essential. It is the prime force upon which industrial and social stability depend.
other fittings have a tendency to produce eddies, and

Personnel in German Power Plants

According to the VDI-Nachrichten of February 10, 1926, a recent survey showed that 31 large German steam power plants having a total capacity of 1,464,000 kw. employ 6078 persons. On the average there is one executive for every 10.5 workmen. There are on the average 5.94 persons per 1000 kw.; this number in some plants is only 3 and in others 13.5 persons. In one plant, for an equally high efficiency for 5000 operating hours per year, there are 1.3 persons per 1,000,000 kw-hr.

In power plants using raw brown coal one fireman is used on the average per 16,145 sq. ft. boiler heating surface. In plants using pit coal one fireman per 10,763 sq. ft. of boiler heating surface, and in municipal power plants one fireman per 80,729 sq. ft. of boiler heating surface.

The Bureau of Yards & Docks, Navy Dept., Washington, D. C., is asking bids for motor generator sets for Service at Pearl Harbor, Navy Yard, Special Specification 5200.

Italian Plant Burns Peat Gas

PRODUCER USED TO GENERATE GAS FOR BOILER FUEL IN 15,000-KW. PLANT. BY CHARLES J. WEBB

IN VIEW of the high cost of coal in the country, attention has within the past few years been devoted to methods of utilizing the deposits of peat which abound in certain parts of Italy for the generation of electric power. One of the most recent and important installations of the kind is that which has been established at Torre del Lago near Lucques by the Società Torbiere d'Italia. A full description of the plant was given in a recent issue of the Italian journal "Industria," from which we learn that the peat is treated in Mond-type gas producers, the gas being utilized for the firing of the boilers which supply steam for the running of the turbo-generators.

Peat is obtained from a deposit on the banks of Lake Massaciuccoli, where there are several seams of a thickness of about 14 to 15 ft.; it is estimated that no fewer than 12,000,000 t. are available. The deposit is worked by means of grab cranes; the buckets, which have a capacity of 53 cu. ft., make about 60 grabs per hour and for the most part work under water, the peat being for a great portion of the year submerged. The peat when extracted has a dark brown color, is of a fibrous character, and contains as much as 85 per cent moisture. It is first allowed to dry in the open air until the humidity falls to about 35 per cent, under which condition a cubic meter (35.31 cu. ft.) weighs 880 lb., the carbon content being 16.42 per cent; that of volatile matter 32 per cent and the calorific value 2100 calories.

When air-dried, the peat is loaded into barges and transported to the gasification plant, about 1¼ mi. away, where it is transhipped by grab cranes into hoppers which feed the gas producers. At present six of these are in operation, but a further two units are being added. The producers have a diameter of 18 ft. and a height of 25½ ft.; each is capable of gasifying 3 t. of peat per hour under normal conditions and 4 t. per hr. when accelerated. The peat is fed to the producers at the top and passes through three zones, the temperatures in the respective zones being approximately 150 deg., 450 deg. and 800 deg. C. At the base a blast of air with 80 per cent moisture is injected into the producer. The resulting gas which leaves the producer at a temperature of about 90 deg. C. has an average composition of CO_2 8.04 per cent, H 17.12 per cent, CH_4 5.88 per cent, CO 20.80 per cent, O 0.02 per cent and Az 48.16 per cent.

When the whole eight units are in operation, the battery of gas producers is expected to yield about 1,412,000 cu. ft. of gas per hour under normal conditions and about 2,118,000 cu. ft. per hr. when accelerated to meet peak load demands. Before its utilization for boiler firing purposes the gas is heated for the separation of its utilizable chemical products. It is first passed through a Glover tower 16 ft. 4 in. in diameter and 49 ft. in height, in which the ammonia content is deposited in the form of sulphate of ammonia, the yield being given as 110 lb. per ton of anhydrous peat. From the Glover tower the gas passes to a washing tower 16 ft. 4 in. in diameter and 52½ ft. in height, filled, like the Glover tower, with sandstone rings and on which a fine rain of water falls. The water is collected at the base of the washer from which it is conveyed to another tower 11 ft. 9 in. diameter and 52½ ft. high, where it is utilized to heat and moisten the primary air for the gas producer.

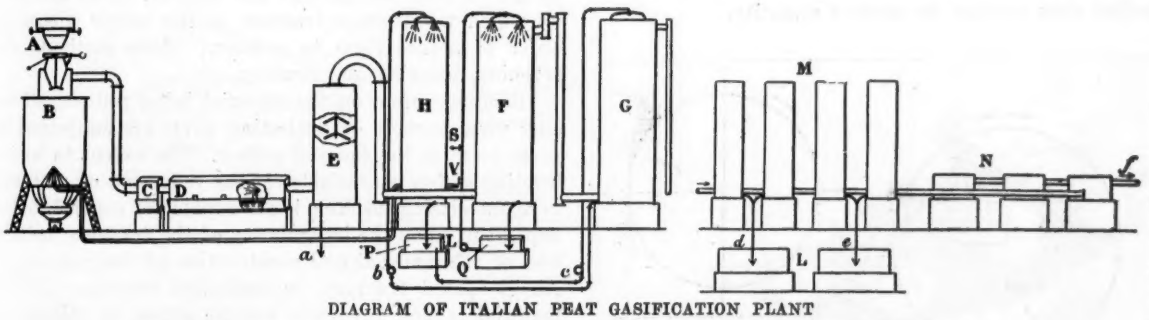


DIAGRAM OF ITALIAN PEAT GASIFICATION PLANT

A Peat Truck
B Gas Producer
C Hydraulic Valve
D Gas Washer
E Dust Remover
F Glover Tower
G Washing Tower
H Primary Air Heater
L Tar and Tar Water Tanks
M Tar Condensers
N Scrubbers
P, Q Tanks
S Sulphate Solution Pipe
V Primary Air Pipe
A Dust Removal Connection
B Washing Tank Connection
C Washing Water Pump
D, E Tar and Tar Water Pipes
F Pipe Conveying Gas to Boilers

On emerging from the washing tower the gas, which is then at a temperature of about 70 deg. C., is directed to a battery of sheet-iron condensers 32 ft. high, provided with cooling coils in which the water and tar in the gas are condensed, two large tanks serving for the storage of the tar and tar water. The gas, the temperature of which is now about 40 deg. C., next passes to a battery of scrubbers, where it is freed of any remaining traces of water, and is then piped direct to the boilers, no gas holder being employed as a measure of economy in installation cost; a small gasometrical bell is, however, provided at the outlet from the condensers, this serving as a sort of valve controlling the primary air inlets to the gas producers.

The plant in which the gas is utilized comprises eight Tosi vertical-tube boilers. The electricity generating plant will eventually consist of three sets of 5000-kw. turbo-generators producing 16⅔ cycle alternating current at 4000 v. at 1000 r.p.m. At present two generating sets are in operation, the current output being utilized for traction purposes on the Spezzia-Pisa-Leghorn and Pisa-Florence electric railways. The boilers are normally fired by peat gas but provision has been made so that tar or even pulverized peat may be utilized. It is estimated that when fully completed the Torre del Lago installation will be able to supply current to the extent of 30,000,000 kw-hr. and produce 5000 t. of tar and an equal quantity of sulphate of ammonia per year.

Principles of Coal Pulverizing Machinery

CONSIDERATION OF PHYSICAL CHARACTERISTICS OF COAL AND EFFECTIVE METHODS OF PRODUCING FINE POWDER. BY S. C. MARTIN

IN DESIGNING a machine for pulverizing any material, the physical features of such material must be thoroughly understood and receive careful consideration in order that the most efficient operation may be assured. In addition to other properties, coal possesses extremely variable grinding characteristics. These characteristics depend mainly upon the class to which the fuel belongs and upon the amount of moisture present when the material enters the pulverizer.

Surface moisture, which renders difficult the reduction of any material to extremely fine powder, varies to a considerable extent in samples of coal. Moisture content in samples of freshly mined coals, not including lignites, may be as high as 20 per cent. Exposure to the weather may change this amount considerably, the smaller sizes holding the greater quantity.

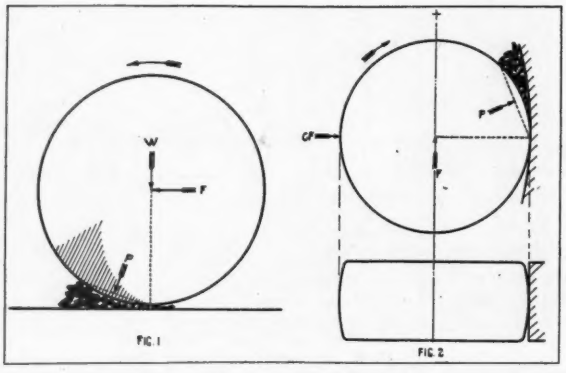


FIG. 1. THIS ILLUSTRATES A METHOD OF PULVERIZING BY MEANS OF A ROLLING WEIGHT

FIG. 2. INSTEAD OF WEIGHT, PULVERIZATION IS EFFECTED BY CENTRIFUGAL FORCE ACTING IN A HORIZONTAL PLANE

In most cases moisture content in coal after pulverization is a hindrance in the successful handling of the material, damp powdered coal being difficult to transport or to hold in storage. Moisture present in pulverized coal may cause it to adhere to the interior surfaces of pipes and bins in which it is confined and to the interior parts of the pulverizer. Deposits of damp powdered coal made under pressure will often pack so firmly that a sharp tool used with force is necessary to remove them.

As it is now economical, in a majority of cases, by means of driers to reduce the moisture in coal to a small percentage, it should not be necessary, as a general rule, to take this factor into consideration when designing a machine to pulverize this material.

Coal possesses, to some extent, the properties of an abrasive and where the fine powder is carried along by a current of air at any considerable velocity and in contact with metal surfaces, the action of the pulverized material on the metal is similar to that of a sand blast, projections in the path of the coal and air being rapidly worn down, cracks and crevices enlarged, and joints opened up.

Powdered coal when dry has little surface tension, its action when confined being comparable to that of a liquid, and the material will flow in a stream through the smallest crevice.

Coal dust in suspension in air that is confined, forms an explosive mixture under certain conditions, which may then be ignited by an open flame or even a spark of electricity. Accumulations of damp powdered coal in the interior of pipes and bins are liable to spontaneous ignition and combustion.

The degree of hardness of coals varies through a considerable range, from that of the friable bituminous coals to hard graphitic anthracite.

METHODS OF PRODUCING POWDER

In the process of pulverization of material of the nature of coal, we have at our disposal three methods by which we produce fracture of the larger pieces in order to reduce them to powder. These methods are crushing, shearing and bending.

Bending action on the material being pulverized occurs when corners or projecting parts are subjected to pressure or to the force of a blow. The extent to which bending action is available for the reduction of material in a pulverizing machine is not capable of control, being dependent upon the irregularity of the fracture, brittleness of the material and construction of the pulverizer. An elongated fracture, or laminated structure of the material is most favorable for the action of this force. Resistance of material of the nature of coal to breakage from bending is in the neighborhood of four per cent of that which it offers to crushing.

Shearing of material in a pulverizing machine is accomplished mainly by attrition, either of the material upon itself or upon the parts of the machine with which it forcibly comes in contact. Attrition is present and aids in the reduction of material in all types of pulverizers. Resistance of material of the nature of coal to a shearing force is approximately 1/5 to 1/10 of that which it offers to crushing.

Crushing is the primary method usually employed in reducing pieces of material into smaller particles, especially where the pieces are of comparatively large size when introduced into the machine. Crushing may be accomplished either by steadily applied pressure, or by impact. Impact may be against the material while in suspension, or when in contact with a part of the machine. The surfaces of the machine elements through which the force is applied may be plane, rounded, or angular. Ultimate crushing strength of coal varies from a few hundred pounds per square inch in bituminous coals, to as high as 3000 lb. per sq. in. in some samples of anthracite.

In order to compare the relative advantages of shearing and crushing as methods of reducing material of the nature of coal to fine powder we may assume the original pieces to be of cubical form, and that the smaller particles resulting from succeeding reductions also are cubes with each successive reduction producing cubes of equal dimensions.

In this case a crushing force must increase as $\sqrt[3]{a}$

if effective action is to continue on the same amount of material as the particles become smaller while force required to shear must increase as $3x^3\sqrt{a-1}$, where (a) represents the number of particles produced.

Minimum force required to shear then will be approximately three times that required to crush, but since the material offers practically six times the resistance to crushing that it does to shearing, in the case of the cubes the latter method is the more economical as regards power.

In the practical application of these forces in a pulverizing machine, however, there are numerous factors which influence the results as calculated above.

Types of Pulverizing Mills

Pulverizing mills are variously described as ball mills, ball and tube mills, roller mills, and impact mills, but with regard to the general method of construction, these machines may be grouped into four general classes.

1. Roller mills. In this type a metal element travels in a prescribed path in contact with a circular track or grinding surface on which the material to be pulverized is distributed.
2. Beater mills in which a rapidly revolving metal beater or hammer strikes the material which is in suspension and throws it with force against a stationary or moving part of the machine, or against other material that is being pulverized.
3. Tumbling mills. Here pieces of material, such as metal balls or other shapes, or pebbles, are agitated with the material to be pulverized in a container.
4. Grinding mills.

Roller Mills

In Figs. 1, 2 and 3 are illustrated three methods of applying a rolling element to the pulverization of material.

In Fig. 1, F is the force applied to cause rotation, P is the direction of resultant pressure on the material, and W is the direction of pressure caused by weight. In this type of mill where the element rolls along a horizontal surface, its momentum causes pressure and impact on any material on this surface with which it comes in contact. This pressure is augmented by leverage, the action being similar to that of a jaw crusher, being more powerful nearest the instantaneous center or point of contact of the roller with the surface over which it travels. Weight of the roller also causes pressure downward in a vertical direction. The relative magnitude of the force of impact acting in a radial direction is indicated by the shaded portion of the illustration.

In Fig. 2 the same forces are in action as in (a) except that centrifugal force replaces weight and acts in a horizontal plane. Centrifugal force increases as the square of the speed. The curvature of the ring or track in this construction allows a somewhat more direct crushing action in front of the roller.

In Fig. 3 centrifugal force acts in a vertical plane and there is available a greater leverage on account of the rotative force being applied at a greater distance from the center of the roller.

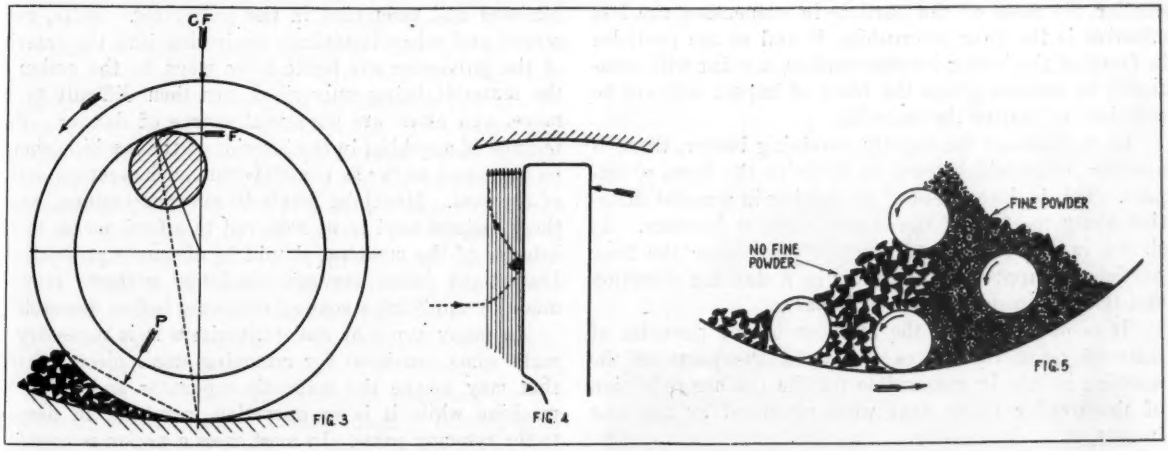


FIG. 3. CENTRIFUGAL FORCE ACTS IN A VERTICAL PLANE, WITH ECCENTRIC POINT OF APPLICATION GIVING GREAT LEVERAGE. FIG. 4. AIR CURRENTS ALONG THE FACE OF A HEATER MAY CHANGE THE DIRECTION OF A PARTICLE BEFORE IT CAN BE THOROUGLY PULVERIZED. FIG. 5. IN A TUMBLING MILL, FINE POWDER MAY CUSHION THE LARGER PARTICLES AND SO REDUCE THE EFFICIENCY OF OPERATION

Material piled too deep in the path of these rollers tends to decrease the crushing action of the particles. Fine powder allowed to remain with the larger particles in the pulverizer may accumulate in the interstices of the collected material that is being acted upon and cause it to offer increased resistance to the crushing force.

The limit of crushing in this manner is reached when the combined area of cross section of the particles on which the force acts is of sufficient extent to cause the applied pressure per unit of area to remain below that of the crushing strength of the material of which the particles are composed.

In order not to resort to excessive pressures in producing finer powder by crushing in this manner, the contact area of the crushing elements and therefore the amount of material acted upon at any one time by these elements must be limited. It becomes necessary then to increase the number of these elements or their speed or both in order to maintain quantity production as the particles become finer.

Centrifugal force may be utilized for producing greater pressure without adding greater weight to the moving elements, and increasing the speed will then result in greater pressure for crushing.

Beater Mills

Mills of this type comprise a variety of arrangements of revolving beater blades or hammers, and stationary obstructions such as deflectors and breakers. The beaters strike the material as it is introduced into the machine, crushing it by impact and throwing it with force against the stationary parts.

A revolving beater which acts upon material in suspension should produce the maximum of fine particles on the first impact, for, although impact of the material against the metal parts of the machine is the principal factor in accomplishing the reduction of the larger pieces it is not so effective a method of producing the finer powder. According to the law of impact of bodies, the smaller the mass of the particle in suspension the less effective is the blow in crushing it and as the particles in front of the beater become smaller, a point will eventually be reached where the force of impact will not be sufficient to shatter the material.

In the case of the rapidly revolving beater, there is another factor which tends to diminish the force of impact. This is the current of air flowing in a radial direction along the face of the beater blade or hammer. As shown in Fig. 4, this air current may cause the finer particles to approach the beater in a slanting direction and thus diminish the force of impact.

It is probable that the attrition of the particles of material upon themselves and upon the parts of the machine is largely responsible for the further reduction of the smaller pieces that were produced by the first impact.

Tumbling Mills

In tumbling mills employing crushing elements of rounded contour, the pressure exerted upon the material to be reduced may be concentrated upon an exceedingly small part of the surface of the crushing element. To this pressure is added the impact so that a great amount of force can be concentrated upon a small quantity of material, resulting in the production of extremely fine powder. Fracture of the material from bending and shearing also takes place in this type of pulverizer and is caused by the movement of the material and the crushing elements in the container as the latter rotates on its axis. In this type of mill it is impossible on account of the construction of the machine to employ a high speed of rotation so that to get the most effective action, the fine powder must be blown away as rapidly as formed, otherwise its presence between the larger particles will cause a cushioning action as shown in Fig. 5.

In summing up the relative advantages of the foregoing methods of reducing coal to fine powder, we find that impact on material in suspension is more effective when the material acted upon is in pieces of comparatively large size.

That attrition or wearing away of the surface of the material is the most effective method of reducing the finer particles to powder.

That as regards strength of material of the nature of coal it requires approximately one-sixth of the crushing force to shear and one-twentieth of the crushing force to produce fracture by means of bending.

Friction Assists in Drying

Friction of the moving parts of the pulverizer and of the material being pulverized produces heat which, provided it does not become excessive, is useful for drying the coal while it is being pulverized. A moderate degree of heat also assists in preventing the coal from absorbing further moisture after it has been dried before entering the pulverizer. This drying process is assisted in effecting separation of the fine particles by the currents of air passing through the machine.

Replacements

Various interior parts of the pulverizer with which the material comes in contact in the process of pulverization are subject to wear, and must be replaced from time to time in order to maintain efficient operation. Such parts should be as few as possible, of low cost, and easily removed and assembled in the pulverizer. Bolts, nuts, screws and other fastenings projecting into the interior of the pulverizer are liable to be worn by the action of the material being pulverized, are then difficult to remove, and often are an actual source of danger. Fastenings of any kind in the interior of the machine should be protected as far as possible from such wearing action of the coal. Machined joints in exterior casings, where these casings need to be removed to afford access to the interior of the machine, should be of ample proportions. Dust tight joints between machined surfaces may be made by applying a coating of grease before assembling.

In many types of coal pulverizers it is necessary to make some provision for removing small pieces of iron that may escape the magnetic separator and enter the machine while it is in operation, resulting in damage to the rotating parts. In most cases a pocket is provided in the wall of the grinding chamber, into which the foreign material falls and may then be removed through an opening communicating with the exterior of the machine, which may readily be opened and closed by means of a door. Care should be taken in locating these exterior openings that there will be no danger of material being forcibly thrown out by the rotating parts of the machine while it is in operation and while the door is opened to remove foreign material.

Successful operation of a machine for pulverizing coal depends not only upon the method employed for reducing the material to powder, but also upon the manner of removing the fine material and of feeding the coarse material to the machine.

Study of the mechanism of corrosion and the factors effective in its control in steam power plant operation is being conducted by the Bureau of Mines, Department of Commerce, at its Pittsburgh, Pa., experiment station. The purpose of this investigation is to obtain data on the amount of hydrogen concentration that should be maintained in the boiler water in order to reduce corrosion to a negligible proportion. In economizer tubes and feed lines especially, dissolved oxygen in the water causes a great deal of corrosion. Elimination of dissolved oxygen can be partly effected by deaeration, but this does not wholly remove the oxygen. If the hydroxyl concentration can be controlled to suit the conditions it can be utilized to control the oxygen.

Tendencies in Steam Turbine Design*

A Review of the Steam Turbine Situation Discloses Many Interesting Developments. The Use of "Tailor-Made" Turbines Is Questioned

IN REVIEWING the outstanding developments in steam turbine design during the past year one is impressed by the large number of different types of units that have been constructed. Ever since the turbine was first placed in commercial service some twenty-five years ago, each year has been marked by increases in the size of units. Last year, however, in addition to the usual increase in size of turbines over those of the preceding year, we find that many new shapes and arrangements of parts were evolved. This is due to the fact that much planning and development work started several years ago was consummated last year. To indicate the nature of some of these new designs we will review briefly some of the more important installations recently completed.

At the Philo station of the Ohio Power Co., two 40,000-kw. single-cylinder turbines running at 1800 r.p.m. were installed. These units are supplied with steam at 550 lb., 725 deg. total temperature and are designed for a single stage of reheating, the steam being withdrawn from the turbine at a pressure of 155 lb. gage and returned to the boiler room for reheating at a temperature of 725 deg. F. It is then expanded through the remaining stages of the turbine to a pressure of approximately ½ lb. per sq. in. absolute at the turbine exhaust. This marks the consummation in this country of Ferranti's dream of a reheating cycle.

Multi-cylinder compound turbines of 60,000-kw., 52,000-kw., and 50,000-kw. capacity, respectively, built by three different manufacturers and designed for the same steam conditions and a single stage of reheating, as described previously for the turbines in the Philo Station, are now in operation at the new Crawford Avenue Station of the Commonwealth Edison Co. of Chicago.

A 3000-kw. turbine designed for a steam pressure of 1200 lb. per sq. in. gage and a steam temperature of 700 deg. F. at the turbine throttle has just been completed by the General Electric Co. for installation in the Edgar Station of the Edison Electric Illuminating Co. of Boston. This machine is designed to operate against a back pressure of approximately 375 lb. per sq. in. The steam from this unit will be returned to the boiler house, where it will be reheated to 700 deg. F. and will then be discharged into the main header of the station. This turbine will be in operation shortly.

At the Colfax Station of the Duquesne Light Co. the Westinghouse Co. has recently installed two 30,000-kw. turbines arranged so that the steam can be bled out at four different points for feed water heating. The operating pressure at the throttle is approximately 260 lb. gage. The feed water is heated up to a temperature of about 350 deg. F. before it is returned to the boiler. This marks the extreme development of the regenerative cycle in turbine room operation.

The first of two 50,000-kw., 62,500-kv.a., 1800-r.p.m. tandem compound, turbo-generators for the new Richmond Station of the Philadelphia Electric Co. has been completed and placed in service. The G. E. Co. also has under construction two 60,000-kw., 1500-r.p.m. turbo-generators for the New York Edison Co. Each of these units will consist of a single cylinder and a single generator.

Present Day Trends in Turbine Design

This brief survey gives an indication of the trend of turbine design. The outstanding tendencies in turbine design at the present time are as follows:

1. The use of a single stage of reheating for steam pressures of approximately 550 lb. per sq. in. gage at the turbine throttle.

2. The use of multi-cylinder, tandem compound and cross compound turbines for capacities of 40,000 kw. and larger both with and without a single stage of steam reheating.

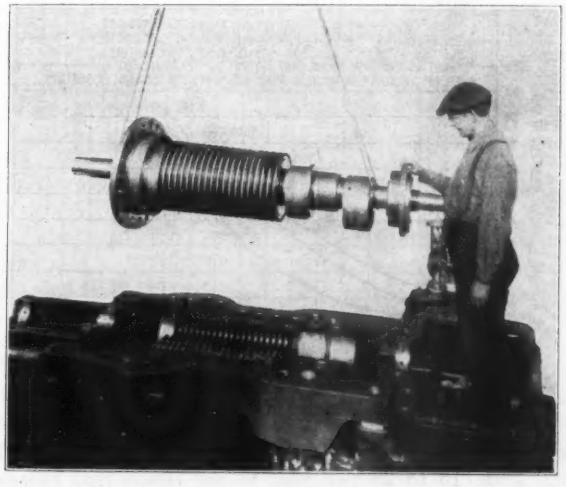


FIG. 1. 1200 LB. PRESSURE G. E. TURBINE WITH ROTOR AND TOP HALF OF CASING REMOVED

3. The tendency on the part of several operating companies to call for larger and larger turbines of single cylinder design. This latter trend is best exemplified by the 60,000-kw. single-cylinder turbines which are being built for the new Fourteenth Street Station of the New York Edison Co.

4. The limiting of the steam temperature at the turbine throttle to a value not in excess of 725 deg. F.

Use of Turbines of Special Design

There has been a tendency to install "tailor-made" turbines in many of the new power stations. In the past year a total of 14 new and special designs were completed. This practice of making each turbine to order to fulfill special conditions or to incorporate the ideas of the buyer is desirable in that it contributes to the progress of the art yet it must not be carried too far. It should be remembered that heavy development charges are involved in bringing out new turbine designs, and that care should always be exercised to keep out eccentric designs, and not multiply unnecessarily the number of designs which are for all practical purposes equivalent. The industry should strive to develop a machine

*Abstracted from the 1925 serial report on Turbines of the Prime Movers Committee of the N. E. L. A.

of the highest practicable efficiency and at the same time keep the variety of designs to the smallest practicable number.

It must not be inferred from this reference to the practice of building "tailor-made" turbines that all large turbines built recently are of this type, for this is not the case. As a contrast, it may be noted that during the last year a total of five 30,000-kw. turbines and nine 20,000-kw. turbines of the new Westinghouse multi-exhaust design have been placed in operation. The General Electric Co. has built over fifty of the 17-stage nominally rated 30,000-kw. turbines, all of substantially the same design.

Possible Increased Ratings From Existing Turbines

In the design of a number of stations there is a definite tendency toward decreased investment costs. In connection with these newer stations designed for operation on the regenerative cycle with steam bled from the

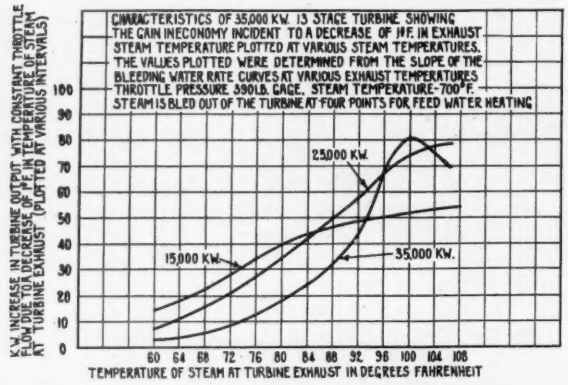

CHARACTERISTICS OF 35,000 KW. 13 STAGE TURBINE SHOWING THE GAIN IN ECONOMY INCIDENT TO A DECREASE OF 10°F. IN EXHAUST STEAM TEMPERATURE PLOTTED AT VARIOUS STEAM TEMPERATURES. THE VALUES PLOTTED WERE DETERMINED FROM THE SLOPE OF THE BLEEDING WATER RATE CURVES AT VARIOUS EXHAUST TEMPERATURES THROTTLE PRESSURE 390 LB. GAGE. STEAM TEMPERATURE-700°F. STEAM IS BLED OUT OF THE TURBINE AT FOUR POINTS FOR FEED WATER HEATING
25,000 KW.
15,000 KW.
35,000 KW.
K.W. INCREASE IN TURBINE OUTPUT WITH CONSTANT THROTTLE FLOW DUE TO DECREASE OF 10°F. IN TEMPERATURE OF STEAM AT TURBINE EXHAUST (PLOTTED AT VARIOUS INTERVALS)
0 10 20 30 40 50 60 70 80 90 100
60 64 68 72 76 80 84 88 92 96 100 104 108
TEMPERATURE OF STEAM AT TURBINE EXHAUST IN DEGREES FAHRENHEIT

FIG. 2. PERFORMANCE OF 35,000-KW. TURBINE WITH VARYING TEMPERATURES AT EXHAUST NOZZLES

turbine at from two to four points for feed water heating, from 15 to 25 per cent of the steam that enters the throttle is bled out before it reaches the last stage of the turbine.

In many of these stations, the steam pressure at the turbine throttle is approximately 375 lb. per sq. in. If turbines, which were designed several years ago, before the regenerative cycle was in common use, are installed in these new stations, and are operated at the normal ratings for which they were designed on the regenerative cycle, the last stages of the turbine will be very much underloaded. In some cases this method of operation makes it necessary to modify slightly the design of the first stage nozzles in order to admit a larger amount of steam to the turbine.

It is believed that much can be done by the turbine manufacturers in the direction of decreasing the investment in turbo-generators, station buildings and other station equipment, if they will make a careful study of the leaving losses in connection with existing designs of turbines. Such changes, it is believed, would add but little to the shop cost, provided no changes were made in the low pressure section of the turbine. Development of better methods of ventilating generators should make it possible for the manufacturers to build generators which will take care of the greater maximum outputs from the turbine without proportional increase in generator costs.

Potential Capacities of Turbines Designed for the Regenerative Cycle

Provision is being made in connection with most of the turbo-generators now being built so that the generator can be quickly disconnected from the turbine and run as a synchronous condenser in the event that the turbine is out of service for inspection or repairs. The pinch for station capacity usually comes during the fall or winter months and is often due to an unexpected outage of the steam end of one of the large turbo-generators. To meet such contingencies, it is to be borne in mind that in those stations operating on a regenerative cycle, additional capacity may be made available by shutting off the steam which is bled from the higher stages of the turbine and letting this steam, which is normally bled out for feed water heating, pass all the way through the turbine to the condenser. Although this results in decreased feed water temperature and an increase in the station coal rate per kw-hr., it is not likely that this increase in station coal rate will limit the station output due to lack of boiler house capacity if it is possible at the same time to keep one of the turbo-generators out of service.

The increased output from the steam end may be taken care of by the generator in two ways:

1. The generator of the turbine which is out of service for overhauling may be operated as a synchronous condenser carrying a large percentage of the wattless current for the station and making it possible for the other turbo-generators to carry more than the normal rated amount of power current.

2. If the emergency arises during the winter months, the circulation of cold water through the generator air coolers will allow some overload to be carried by the generator, due to the lower temperature of air entering the generator.

This additional potential capacity inherent in a turbine designed for operation on the regenerative cycle is a valuable asset.

Additional Advantages Incident to Operation on the Regenerative Cycle

It is of interest to note that the Rankine cycle efficiency ratios at which the high pressure stages of modern large turbines operate are higher than for the low pressure stages which fall in the zone where the steam is wet. This helps to increase the overall efficiency for the turbine operated on the regenerative cycle. It has been thought that for turbines operating on the regenerative cycle there is a definite increase in the Rankine cycle efficiency ratio for the lower stages of the turbines, due to the withdrawal from the turbine of a considerable amount of moisture, together with steam bled for feed water heating. This has not been definitely proved. Inspections made recently have indicated reduced blade erosion at points just beyond successive bleeding points. This tends to bear out the aforementioned theory. More evidence will be available within a year's time.

An interesting method of analyzing turbine performance has been developed by the General Electric Co. The problem of analyzing turbine performance becomes very involved. In connection with modern stations with turbines designed for 3- and 4-stage bleeding of feed water heating, the following conflicting factors must be considered:

1. Only that energy generated by the steam which goes all the way through the turbine to the condenser is appreciably affected by a change in vacuum at the turbine exhaust.

2. An increase in vacuum at the turbine exhaust is accompanied by a reduction in condensate temperature, which in turn means that more steam must be bled out of the turbine at the low pressure bleeding point for feed water heating, which then tends to increase the heat consumption per kw-hr. generated by the turbine.

3. An increase in vacuum increases the total steam volume and the steam velocity leaving the last wheel of the turbine. The increase in the kinetic energy loss in steam going to the condenser results in a decreased Rankine cycle efficiency ratio. The greater the load carried by the turbine, the more marked this effect becomes.

More careful methods of analysis must be used in order to show the net effect of all of these conflicting factors. Figure 2 shows what is believed to be a new and rather ingenious method of analyzing turbine performance. The three curves shown are not the results of actual tests (the turbine has not yet been placed in operation). These curves represent, however, the results of a most painstaking study, made jointly by the engineers of one of our member companies and the designing engineers of the General Electric Co. The three curves shown are really the first differentials of the bleeding water rate curves for the three loads calculated on the basis of 4-stage bleeding for heating of feed water.

The method of analyzing turbine performance, shown by Fig. 2, is of great value in evaluating surface condenser performance, both in connection with design and operation.

Operation of Mercury Vapor Turbine at Hartford

The Hartford Electric Light Co. has prepared a statement on the operating experiences in connection with the mercury vapor turbine in the Dutch Point Station in Hartford. While the entire statement cannot be given here in detail, some of the principal points are listed as follows:

"The first mercury installation was started during September, 1923, and operated approximately one year. During that time it ran about 2400 hr. and turned out 2,500,000 kw-hr. from the mercury and 54,000,000 lb. of steam at 200 lb. pressure and 480 deg. F. No difficulties whatever were experienced with the mercury cycle. Difficulties that appeared from time to time were entirely mechanical or electrical. The result of the experiment has proved to our entire satisfaction that the mercury vapor process is a complete success. As a result of the experimental data and experience, the General Electric Co. has designed and will shortly ship to us a new form of mercury boiler of the water tube type to replace the original boiler which was of the fire tube type. The turbine itself was a single-stage machine, designed for an easy replacement of buckets, as erosion was anticipated. There has been no erosion of the buckets from the mercury vapor, however, and this single-stage, low efficiency machine is now being replaced by a 3-stage machine. The new apparatus is expected to be in operation shortly and should give much better results than were even those obtained with the first experimental outfit. There is undoubtedly much development work to be done on this type of apparatus before a large size unit can be properly designed. From the results of preliminary tests, however, it may be expected that a large unit will be produced within a reasonable time."

Manufacturers' Statements

In the various manufacturers' statements which are included in the turbine report, the Allis-Chalmers Manufacturing Co. reports that two 20,000-kw. steam turbo-alternators were placed in service at the Peoria Station of the Illinois Electric Power Co. for operation with 350 lb. per sq. in. steam pressure, 250 deg. superheat and 28 to 29½ in. of vacuum. They further report the construction of a 30,000-kw., 80 per cent power factor unit for installation at Waukegan, Ill., and also

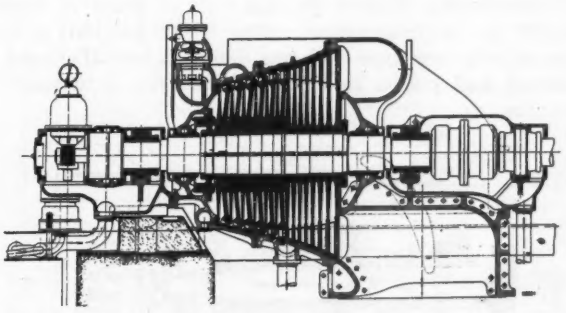


FIG. 3. STANDARD 30,000 TO 50,000-KW. TURBINE, BROWN BOVERI & CO.

have sold a 50,000-kw. unit to the Waukegan Generating Co. at Waukegan, Ill. This unit is of the two-cylinder, tandem compound, single-generator arrangement with direct-connected exciter. Steam pressure at the throttle is to be 600 lb. gage with a total steam temperature of 725 deg. F. The design is based on a vacuum of 29 in. referred to a 30-in. barometer. The preliminary work on the design of this unit is well along.

The American Brown Boveri Electric Corp. reports that plans are under way whereby Brown Boveri & Co. will actively enter the market for large steam turbo-generators in the United States. It is planned at the present time to do the design work in Switzerland and also to manufacture there the expensive details, such as blades, governor gear, control valves, generator coils and other such material. The heavy castings will be made in this country. The machines will be assembled and given a thorough running test in an American shop before shipment to the purchaser.

The normal Brown Boveri turbine for larger capacities is a combined turbine. The high pressure part is of the impulse wheel type, the intermediate and low pressure parts are designed on the reaction principle. Figure 3 shows the section of a similar type, but for 30,000 kw. to 50,000 kw. running 1800 r.p.m.

The Société Alsacienne De Constructions Mécaniques of Belfort, France, report that improvements have been made mainly in the design and manufacture of nozzles and buckets. Studies and investigations are still under way but material improvements have already been secured. Tests show that good efficiencies may be obtained with a limited number of expansions (6 to 10), providing the blading is of proper shape and the machining irreproachable. They are at the present time

building a set for 50,000 kw. continuous rating at 1500 r.p.m. The guaranteed water rate of this machine is 8.97 lb. per kw-hr. at terminals under a load of 45,000 kw., the steam conditions at the throttle 328 lb. per sq. in. and 707 deg. F.; the vacuum at the turbine exhaust being 29.01 in. referred to a 30-in. barometer.

The General Electric Co. report that they have put four machines in service operating at 550 lb. per sq. in. steam pressure at the throttle and 725 deg. F. total temperature. The first 40,000-kw. unit in the Philo Station was placed in commercial service September 22, 1924. So far no difficulty has been found with the operation of the reheat cycle and the anticipated economies of reheat have been fully realized. The 60,000-kw. cross-compound unit installed at the Crawford Avenue Station of the Commonwealth Edison Co. has carried loads of over 55,000 kw. without reheat. This 60,000-kw. unit is of an entirely new type and was designed, manufactured, erected and placed in commercial service in nineteen months.

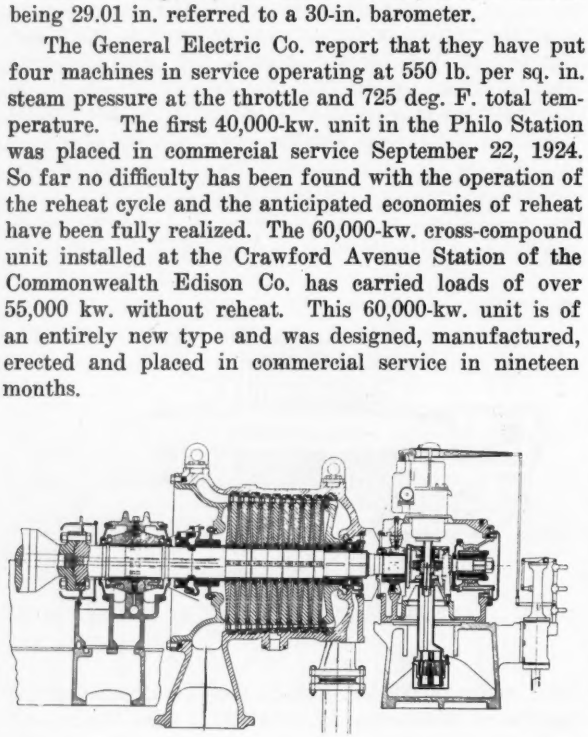


FIG. 4. 47,000 KW. 1800 R.P.M. 10-STAGE HIGH PRESSURE UNIT OF A 60,000 KW. GENERAL ELECTRIC CO. TURBINE

The General Electric Co. also reports the construction of a 77,000-kw., cross-compound steam turbo-generator of the non-reheat type, designed for 550 lb. pressure for the Crawford Avenue Station. This turbine is designed to operate on the regenerative cycle, steam being bled out at four points to heat the feed water to a final temperature of 350 deg. F. They report that the turbine designed for operation at steam pressures of 1000 to 1200 lb. for installation in the Edgar Station, near Boston, is now in test and will be placed in service within a few months.

The first of the 50,000-kw., 1800-r.p.m. units for the Philadelphia Electric Co. have also been installed and placed in operation. These units are of the tandem compound type with double flow in the low pressure cylinder. Two 60,000-kw. units are being manufactured for the New York Edison Co. These units will consist of a single turbine element with a single generator.

The Westinghouse Electric & Manufacturing Co. reports the completion of 14 machines of 20,000 kw. capacity and greater during the year 1924. These machines all employ the multi-exhaust low pressure blading. Two 50,000-kw. tandem machines were installed in the Hudson Avenue Station of the Brooklyn Edison Co. and one 50,000-kw. cross-compound machine in the Hell Gate Station of the United Electric Light & Power Co. The 52,000-kw. tandem cross-compound machine, which the Westinghouse Co. placed in operation at the Crawford Avenue Station, has been giving satisfactory service in every respect. The single-cylinder multi-exhaust turbines were of completely new design and while some minor operating difficulties were experienced, these were readily corrected. The design of the auxiliary oil pumps included ball bearings in order to effect easy starting with turbine drive. For the sake of uniformity, the main oil pump was similarly constructed. Three failures proved the misapplication of the ball bearings and in all machines they were replaced by the ordinary lubricated babbitted bushings.

Protecting Recreation Grounds While Developing Power

ON MARCH 26 the Federal Power Commission authorized the issuance to the Chelan Electric Co. of a license for a power project at the outlet of Lake Chelan, in the State of Washington. The conditions which the commission attached to its approval indicate the care which it is taking to protect scenic and recreation interests against injury, and how, by proper consideration, power and recreation uses may be adjusted without substantial damage to either. Not only the lake itself but also the entire region beyond and adjacent to the lake is one of great scenic interest, so that the lake is used both as a camp ground during the recreation season and as a means of access to the high mountain country beyond the lake. This is the situation which the commission has sought to project.

In the development of the power it is proposed to raise the lake level from its natural maximum of 1083.5 ft. to 1100, or an increase of 16.5 ft., and at certain times of the year to draw the lake to its minimum natural level of 1079 ft.—operations which will cause a variation of 21 ft. in the level of the lake. This will mean submergence of a portion of the present lake shore. Wherever such submergence takes place, the area is required to be cleared of all trees and brush and kept cleared, so that there will be no dead material projecting above the lake surface. Were the lake, however, to be drawn down to its lowest level during the recreation season, considerable areas of shore line, unsightly even though cleared, would be exposed, particularly at the head of the lake, and it is primarily to avoid this contingency that conditions have been placed in the license respecting the maintenance of lake levels during the recreation season from June 15 to Sept. 15.

The power plant of the Chelan Electric Co. will be controlled by the Washington Water Power Co., and operated in connection with that company's power plants on the Spokane River. The problem, therefore, which the commission had was to adjust the use of Lake Chelan storage with Spokane River storage so as to cause the least practicable loss of power on the system of the Washington Water Power Co., as a whole, consistent with reasonable protection of scenic interests on Lake Chelan.

SOME MEN die a natural death, others stand on busy railway tracks to do their talking, reports the National Safety Council.

Application and Operation of Diesel Engines

CONDITIONS AFFECTING COSTS MUST BE ANALYZED FOR SPECIFIC CONDITIONS. BY G. A. ADKINS* AND R. H. BACON*

DURING THE past 10 yr. the Diesel engine has become an important factor in power production. Engineers in every industry are interested in studying the possibility of applying this prime mover to their power problems. Such a study must involve an analysis of load conditions in order to estimate the number and size of the Diesel engines and determine the total power cost. This cost will be made up of fuel, lubricating oil, operating labor, maintenance and fixed charges for each of the combinations which may be considered.

Engines with direct-connected alternators are coming into widespread use for general power plant service. Belt pulleys, friction clutch pulleys, flexible couplings, and friction clutch couplings are also used to meet specific conditions of load or starting torque. It is possible to arrange various drive combinations such as direct connection of the engine to an alternator with a clutch pulley placed beyond the outer alternator bearing or to

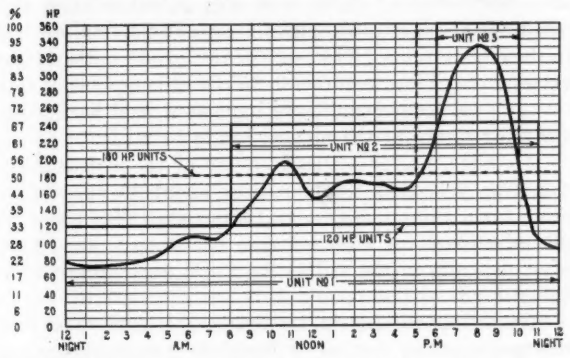


FIG. 1. TYPICAL LOAD CURVE OF A SMALL PLANT SHOWS HIGH PEAK

use a belt drive to the alternator with a friction clutch coupling on the extension shaft for direct connection to a driven machine.

Certain fundamental operation characteristics of the Diesel engine have a general effect on its application.

First—Diesel electric generating sets parallel nicely, making it possible to install several units.

Second—The fuel efficiency of the small engines is practically the same as for larger ones, making it possible to take advantage of the multiple unit idea without loss in over-all plant efficiency.

Third—The fuel consumption curve for the Diesel engine is practically flat through the range from half to full load and units should be arranged so that no engine operates below this.

Fourth—The lubricating oil consumption is practically constant for any particular size of unit, that is, it does not vary with the load.

GRAPHIC LOAD CHARTS ASSIST IN DESIGN

In studying the characteristics of the load, graphic charts plotted from hourly readings are useful. Such charts permit a study to be made of the size units to use and make it possible to figure the operating economy of several combinations.

In the industrial plant it is necessary to take into consideration the steam which may be required for heating or for process work, which, however, does not prove that the Diesel engine may not effect a substantial saving in the cost of producing power. Present studies indicate that the tendency towards the use of higher

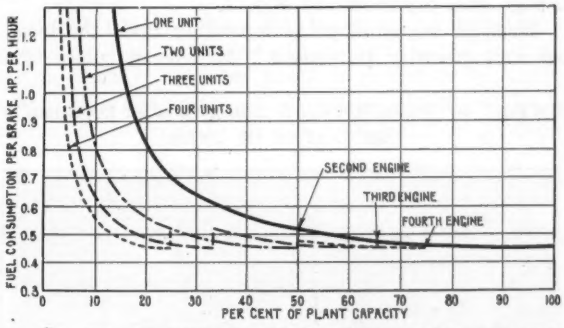


FIG. 2. USE OF TWO OR THREE UNITS DECREASES FUEL CONSUMPTION AT LIGHT LOADS

steam pressures in industrial plants, for combined power and process work, has been carried beyond the economic limit. Many engineers are reaching the conclusion that the use of low pressure boilers for heating and process work, together with a Diesel plant for power, is the solution. With such a combination, the efficiency of power production is totally independent of the changing demands for steam and the over-all operating cost is reduced.

Load curves encountered in the small municipal or public utility power station or in the operation of a hotel or similar service would be similar to Fig. 1. This load could be carried by a 360-hp. engine, two 180-hp. units, or three 120-hp. engines, the most economical arrangement being indicated by probable power costs.

MANUFACTURERS' FUEL GUARANTEES ARE USUALLY CONSERVATIVE

Fuel consumption curves for a plant equipped with from one to four Diesel engines are shown on Fig. 2. These curves are based on typical manufacturers' guarantees, which are conservative in order to permit the use of a wide range of fuel oil.

Referring again to Fig. 1, it will be noted that the different combinations of units have been blocked in on the load curve. At 12:30 a. m. the plant is operated at an average of about 20 per cent capacity and the fuel consumption of a two or three-unit plant during this hour would be approximately 16 per cent less than for the single unit. This reduction in fuel consumption does not take into account the slightly reduced efficiency of the smaller generators which would not change the relation materially. The daily plant factor, as represented by this curve in relation to the plant capacity for a 360-hp. engine is 41.7 per cent. In the case of the two and three-unit plants the average running load of

*Fairbanks Morse & Co., Chicago, Ill. Presented before N. A. S. E. No. 28 and Chicago Section of A. S. M. E., April 17, 1926, during Oil and Gas Power Week at Chicago.

each engine is approximately 70 per cent which accounts for the substantial fuel saving.

Assuming that this is an average load curve for the year, the total horsepower hour output would be 1,387,000 hp. or allowing 12 per cent for generator and excitation losses, the kilowatt hour output would be 910,000 per year. To produce this number of kilowatt hours a 360-hp. engine would consume 101,944 gallons of fuel oil per year at a cost, at 5 cents per gallon, of $5097. The two 180-hp. engines would consume 88,074 gal. per year at a cost of $4404. The fuel cost of the three 120-hp. units would be practically the same as for a plant equipped with two 180-hp. engines under the particular load conditions of Fig. 1.

Fuel oil varies in price depending upon the localities and quantity purchased. An average price of 5 cents per gallon delivered in tank car lots is shown by a recent survey of a large number of plants.

SUMMARY OF OPERATING COSTS INDICATE MOST ECONOMICAL COMBINATION OF UNITS

Number of Units	1	2	3
Size of Units, HP	360	180	120
Fuel oil @ 5¢ per gallon	$5,097.00	$4,404.00	$4,400.00
Lubricating oil @ 55¢ per gallon	867.00	526.00	531.00
Labor	6,000.00	6,000.00	6,000.00
Maintenance 2% on 85% of installation cost	500.00	550.00	600.00
Fixed charges 11.72% on total cost	3,516.00	3,809.00	3,984.00
Total operating cost	15,980.00	15,289.00	15,515.00
KW Hr. output @ 42% yearly plant factor	910,000	910,000	910,000
Cost per KW Hr. with fixed charges	$0.01715	$0.0168	$0.01710
Cost per KW Hr. without fixed charges	0.0137	0.0126	0.0127
Cost for fuel and Lubricating oil	0.0065	0.0054	0.0054

Improved Design Has Greatly Reduced Lubricating Oil Consumption

Lubricating oil consumption while necessarily higher than for a steam turbine or engine is no longer an important item in the cost of operation. A conservative guaranty on oil is 2000 hp.-hr. per gallon. This is the total oil used in all parts of the engine, no grease or other lubricant being required. At this rate the 360-hp. engine would require 1577 gal. or, at 55c per gal., $867 per year. The yearly consumption of the two 180-hp. units would be 952 gal. at a cost of $526 and the three 120-hp. engines 962 gal. at a cost of $531. The two-unit plant is not only better from the standpoint of the fuel cost but that of the lubricating costs as well.

Supervision is another item with important bearing on the total cost of operation. One engineer can easily handle a plant of three units as this is being done every day in hundreds of plants throughout the country.

For a plant of the size in question it is probable that a figure of $2400 a year for the chief engineer and $1800 a year for each of two assistants who would stand watch on the two other shifts, would cover this operating expense. In many industrial establishments the Diesel plant would be under the supervision of the power superintendent with only a part of his time chargeable to the Diesel plant. It is probable that the total cost would not be over $6000 a year. Many plants of this size are actually operating at less than this figure although it is questionable economy to cut too closely on the item of operating supervision. Careful operation of Diesel engines, as in the case with any other piece of machinery, will pay over a long period of years in reduced repair costs.

For estimating purposes the installed cost of a Diesel engine and its accessories can be taken at $70 to $110 per horsepower. A 360-hp. Diesel electric unit, exclusive of building, would cost about $30,000 with the installation ready for operation, provided for fuel storage and similar details. Equipped with two 180-hp. engines the plant would cost about $32,500.

Building and Foundation Costs Vary Over Wide Range

In some cases engines are placed in buildings which are constructed of sheet iron and in other cases the buildings are face brick with limestone trim or tile walls in the engine room. The cost for the building, therefore, varies from as low as $1000 to $15,000 for a plant of this size. Space requirements are important, and head room for the removal of the pistons has to be made.

Foundations for a Diesel engine of the airless injection two-cycle type would require about 40 yd. of concrete for a 120-hp. engine and alternator with about 12 yd. additional for each increase of 60 hp. This, however, depends on the soil so costs will vary from $12 to $25 per yd.

Operating records in hundreds of plants show that the maintenance cost of a Diesel is not excessive and that 2 per cent is ample to build up a fund which will cover all necessary repairs to engines of late design. Modern methods of building are based on the latest practice in metallurgical art. Breakages of main parts have been practically eliminated and when occurring are in nearly every case attributable to negligence in operation or a lack of maintenance.

Interest on the investment, depreciation, insurance and taxes, commonly listed under "Fixed Charges" must be considered on a fair and unprejudiced basis. There is no reason to believe that an assumption of life from 25 to 30 yr. is at all far-fetched. There are not many managers of industrial plants who would be willing to consider depreciating a plant over that long a period so 20 yr. has been selected as a reasonable time in which to write off the investment. On this basis a depreciation reserve of 2.72 per cent has been selected as the depreciation item and if set aside and compounded semi-annually will write off the total investment by the end of 20 yr.

On this basis the total fixed charges for the plant would be, interest 6 per cent, depreciation 2.72 per cent, taxes 1.5 per cent and insurance 1.5 per cent, or a total of 11.72 per cent. Another method of calculating the fixed charge is write-off depreciation on straight line basis and then reduce the interest as the investment is reduced. In this way the fixed charges would total 11.72 per cent as before.

Tabulation of Costs Allows Selection of Most Economical Units

From the analysis of operating costs it is now possible to tabulate the estimated cost of the Diesel plant equipped with the three combinations of units as shown in the accompanying table. It will be seen that the two 180-hp. engines appear to be the best combination from the standpoint of actual operating costs saving $691 per year which is good interest on the added investment of $2500. In addition to reducing the cost, the flexibility of operation and the plant's reliability is greatly increased as one of the engines is out of service each day, permitting careful inspection and allowing time for making any minor repairs or adjustments.

During the consideration of the possibility of applying Diesel engines to any particular power problem such details as fuel storage, cooling water supply, exhaust arrangements, the installation work and training of the plant operators must be considered.

Fuel Storage Is Covered by Fire Regulations

Fuel storage is largely governed by fire ordinances and the National Board of Fire Underwriters, so it is well to investigate these conditions. The farther the tank is away from the building the larger the amount of fuel which can be stored. Up to 21,000 gal. can be stored in a tank above the ground if placed 25 ft. from any buildings. Regulation on storage inside of building is as follows:

(a) In ordinary buildings the gross capacity of tanks shall not exceed 5000 gal.

(b) In fire-resistive buildings the gross capacity of tanks shall not exceed 10,000 gal.

(c) In any building, if in a fire-resistive or detached room cut off vertically and horizontally in an approved manner from other floors of the main building, the gross capacity of tanks shall not exceed 50,000 gal., with an individual tank capacity not exceeding 25,000 gal., provided the insulating sand shall be increased to 12 in. on sides and 18 in. on top.

Storage capacity should be sufficient to carry the plant through unusual transportation tie ups and to enable the buying of oil during favorable market conditions. Tank cars of 10,000 gal. capacity are more nearly standard than those of 8000 or 12,000 gal. but the storage tank for small plants should be large enough to hold at least one tank car of either size and preferably larger so that there will be some supply at the time that the car is emptied. It would seem wise in the case of any plant to provide at least two months' storage. A 10,000-gal. tank would cost in the neighborhood of $500 or from $700 to $900 installed, depending on the freight and necessities of the installation. Two 10,000-gal. storage tanks in the plant considered would store almost three months' supply.

For continuous full load operation the Diesel engine requires from 8 to 10 gal. of cooling water per rated horsepower hour. Outlet temperatures should ordinarily be kept below 130 deg. F. If the available water is practically free from scale forming ingredient and the supply is cheap, the water may be wasted although this hot water is frequently used in process work.

When the water available will form scale at the maximum outlet temperature, it may be treated chemically or rain water can be used to fill the cooling system. Where it is necessary to keep the quantity of make-up water low a closed type of cooler is more suitable than a cooling tower where evaporation and windage run from 2 to 5 per cent. There are various combinations of cooling systems which can be used so the cooling offers no unusual difficulties.

Silencers Can Be Provided to Muffle the Exhaust

Considerable improvement has been made in the exhaust arrangement of Diesel engine plants. In fact it is now possible to locate such plants in residential districts, due to the effective silencing arrangements which are now provided.

It is advisable to have the design work handled by a consulting engineer unless the industrial establishment has an engineering force which is competent to handle work of this character. Where the purchaser prefers to handle the general details, the manufacturer furnishes

FIG. 3. SHOWING HOW MODERN FLEXIBLE UNITS FULFILL INDUSTRIAL REQUIREMENTS

an erector to supervise the installation at the expense of the purchaser. Engines up to about 400 hp. are usually shipped assembled but larger units are shipped disassembled to be erected at the plant so it is always advisable to install a hoist of some type which will handle the various parts. A plant of the size under discussion would require a one-ton hoist.

When the plant goes into operation the manufacturer's representative will see that the operators are instructed on the fundamental points, although this may not be in great detail, and it is up to the operators themselves to get well posted on the finer points of operation.

Operators Must Watch Fundamental Points Carefully

The supply of circulating water must be ample at all times to keep the operating temperatures below the danger point and the cylinder jackets should be kept free from scale. If cylinder jackets become heavily coated with scale, the effectiveness of the cooling water is reduced and the operating temperatures in the cylinder begin to rise. The scoring of cylinders may not always be caused from the cooling water but is always a direct result of overheating which causes an unusual expansion and thus decreases the clearance between the cylinders and the piston. This overheating may be due to one of the following causes:

1—Abnormal operating conditions.
- (a) Overload.
- (b) Faulty exhaust.
- (c) Faulty cooling water supply.

2—Insufficient lubrication.
- (a) Temporary lack of lubrication.
- (b) Poor quality of lubricating oil.

3—Fuel condition.
- (a) Faulty injection.
- (b) Unsuitable fuel.

4—Mechanical conditions.
- (a) Stuck piston rings.
- (b) Loose or tight piston pin.
- (c) Cracked piston head.

The more intelligent the operator the less the repair cost will be and it is not at all uncommon to find plants where the repair costs have been actually less than one-half of 1 per cent of the machinery investment for periods of many years. The engines should be inspected periodically and it is better to inspect too frequently than not frequently enough. It is wise to remove the cylinder heads, pull the piston, and thoroughly inspect the engine at regular times. Some operators do this once a year and others set the time in accordance with their own experience.

Flue Gas Stops Dust Explosions

ENGINEERS OF THE U. S. Department of Agriculture have erected a feed-grinding mill at the experimental farm, Arlington, Va., to demonstrate the practicability of using inert gas from boiler flues for preventing dust explosions. A regular feed-grinding unit for grinding oat hulls has been installed, and a pipe line from the power house brings in the flue gas.

Many dust explosions in feed grinding mills originate at the point where the grain enters the grinding machinery. They are caused by ignition of dust, by sparks, which are often caused by pebbles or pieces of metal coming in contact with the steel grinding plates. A small explosion at the grinder may spread in successive explosions of increasing size throughout the milling system.

Tests have shown that explosions can not occur in an atmosphere containing less than 13 per cent oxygen. By the introduction of flue gas, or carbon dioxide, in sufficient quantity, explosions will be prevented. Numerous other gases could be used to create conditions unfavorable for explosions but flue gas has the advantage of being economical and continuously available. In the experimental mill, a continuous means of ignition is maintained by the use of an electric arc. When the gas is cut off sufficiently to permit the oxygen content of the air to increase, small explosions result. A vent opening to the outside of the building prevents damage to the mill.

Although this mill is equipped for grinding oat hulls for stock feed, the principles involved in preventing explosions by means of inert gas are applicable to mills that grind many other materials. Arrangements may be made with the department for observing the tests, or information on any particular phase of the use of inert gas as a means of preventing explosions may be obtained by writing to the Bureau of Chemistry at Washington, D. C.

Copper Tungsten Electrode

COPPER-TUNGSTEN electrodes, a development which is expected to prove of great value in the fabrication of metals, are now available for use in manufacturing. This announcement is made by the General Electric Co. who evolved the new electrode.

One of the limiting features in many resistance or spot welding operations has always been the copper electrode used, the pure copper not being hard enough when used under the high pressures at high currents common to this type of welding. Usually, after a few welds are made, the surface of the copper electrode in contact with the weld becomes hot enough to anneal the copper, thus making it extremely soft. As a result, the copper tip rolls and mushrooms over the edges, giving a large spot weld which changes the current density, consequently the quality of the weld.

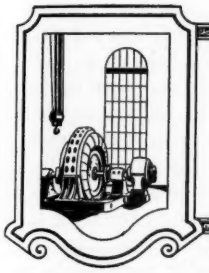
Copper, tungsten, as its name indicates, is a mixture of two metals, one a good electrical conductor and the other exceedingly hard. The alloy has a hardness of 225 (Brinnell) as compared with 82 for hard copper and 30 for soft copper. The compressive strength of the copper-tungsten is 208,000 lb. per sq. in. as against 58,000 lb. per sq. in. for hard copper. The tensile strength is 56,350 lb. per sq. in. compared with 30,000 lb. for soft copper and 50,000 to 70,000 lb. for hard drawn copper.

Copper-tungsten does not anneal at red heat. Thus there is no soft surface metal to roll or mushroom over when used in resistance welding. It has not been found necessary to form the entire electrode point or die of copper-tungsten, but rather to use inserts of this alloy by any one of a number of methods, such as forcing an oversized piece in a hole in the die, brazing a block in the wearing surface or placing pieces in a mold and casting the die around them. The remainder of the die is made of copper as before.

In view of the higher first cost of copper-tungsten, its chief value is expected to be in special applications. It is particularly adapted for use under severe conditions where copper will not stand up, such as hot upsetting rivets electrically, and in facings for clamps for rod welding, split dies for welding steel spokes to both rim and hub of steel wheels and in many other applications where copper cannot be used because of its softness. In such instances, without the use of resistance welding which is now made feasible, it would be necessary to adopt other and more expensive methods of fabrication.

Durability of the new alloy is shown by a recent test, where the number of welds made with one dressing of a copper die averaged ten, while the first test using copper-tungsten inserts gave more than 1000 welds with the die still in good condition at the end of the test. Other tests showed better results. It is therefore expected that the cost of changing the old copper electrodes and redressing them will more than pay for the larger first expenditure for copper-tungsten.

The material has been given the trade name Elkonite and will be manufactured and sold exclusively by the Elkon Works, Inc., Weehawken, N. J., of P. R. Mallory & Co.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Use of Storage Batteries in the Power Plant

A Properly Designed Storage Battery Installation Is of Prime Importance to Every Power Plant Where Continuity of Service Is Demanded. By J. Lester Woodbridge*

DEVELOPMENT of large power stations in recent years, involving remarkable increases in the size of the generating units and steady progress in the application of labor-saving apparatus and in the introduction of devices for improving the economy of heat conversion has called for the introduction of a number of auxiliary power-driven units for controlling the various processes involved in the conversion of the energy of the fuel, first into heat, then into the energy of steam under pressure, then into mechanical power, and finally into electric current. Accompanying this development has arisen the necessity for the automatic control of these various auxiliaries.

Originally much of the power for the operation of such auxiliaries was furnished by steam-driven units, and while this practice is still continued to a certain extent, the introduction of the electric motor in place of the steam-driven unit for many of the important auxiliaries has been found advisable, both on account of flexibility of control and reliability of operation. In addition to these auxiliaries requiring continuous power, there are others, such as remote control switches and rheostats and automatic circuit breakers, calling for intermittent operation for which electric current is required.

The lighting of the power house is also of prime importance, and must be furnished by a source of current which is not subject to interruption, even when the power house is completely shut down.

Use of Direct Current in the Power Plant

Alternating-current motors have been found very satisfactory for the operation of many of the electrically driven auxiliaries, but in other cases such as field excitation, a direct-current supply is required, and in many cases where either alternating current or direct current could be used, the direct current is found to be more flexible, especially where motor speed control is of importance. An important argument in favor of direct-current operation for many of these auxiliaries is the fact that a reserve source of current can be provided in the form of a storage battery which will be instantly available in case of a complete shut-down of the power plant. Even where an alternative source of power is available in the form of a tie line from another station, this is not considered as reliable as a storage battery, since the same disturbance which may have interrupted the operation of the power plant may also have put this tie line out of commission.

The question of electric drives for power plant auxiliaries has been thoroughly covered in the report of the Electrical Apparatus Committee of the National Electric Light Association, published in December, 1924. In this report considerable emphasis is laid on the necessity of insuring absolute continuity of the power house lighting by means of a storage battery, and attention is called to the fact that many power plant designing engineers now consider the storage battery as an essential feature in power house design. This report, however, does not undertake to discuss the question of current supply for field excitation or for the control bus used for the operation of oil circuit breakers, remote control rheostats, etc. These latter constitute an additional argument for storage battery reserve in the power house.

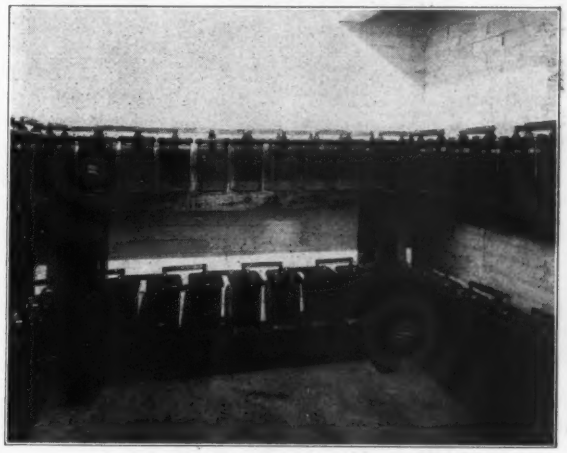


FIG. 1. A STORAGE BATTERY INSTALLATION OF THE ERIE COUNTY ELECTRIC CO. PLANT AT ERIE, PA. USED FOR CONTROLLING THE OPERATION OF 30 OIL CIRCUIT BREAKERS AND ABOUT 1500 W. OF GENERAL ILLUMINATION

Applications of electric current in power house operation may then be grouped into four classes, namely:

(1) Control bus for automatic and remote control oil circuit breakers and apparatus.
(2) Station lighting.
(3) Field excitation.
(4) Motor-driven auxiliaries.

*Chief Engineer, The Electric Storage Battery Co., Philadelphia, Pa.

For all of these a reserve source of energy independent of the station output is important.

Use of storage batteries for control bus protection and operation has long been standard practice, and is practically universal. It is quite common to provide excess capacity in the control bus battery to take care of emergency lighting in the station. In many cases a storage battery of considerable size, suitable for reserve for all classes of power house operations is included as a part of the power house design.

Control Bus Batteries

With a control bus battery the function is somewhat different from that of a battery which is used for the other classes of service in the fact that it not only acts as a reserve in case of failure of the normal source of current, but it also supplies the momentary high current required when the oil circuit breakers are operated, relieving the generator from these excessive demands and permitting the use of a much smaller machine for this

FIG. 2. THE SWITCHBOARD ON WHICH ARE MOUNTED THE REMOTE CONTROL APPARATUS SUPPLIED WITH POWER FROM THE BATTERY SHOWN IN FIG. 1

purpose. In view of this difference in function, it is quite customary to provide a separate battery for the control bus, even where a second, and possibly a larger battery is installed for the other classes of service. Another factor also enters into this differentiation in the fact that for the operation of the oil circuit breakers the minimum permissible voltage is considerably higher than that which will give reasonably satisfactory results for the other applications. This difference has been further emphasized by the recent change in the design of oil circuit breaker control apparatus which has considerably increased this minimum voltage limit.

In general, the method of operation of these power house reserve batteries is to keep them always floating on the constant voltage d.c. bus in parallel with one or more direct-current generators. Thus the battery is kept fully charged and is at all times connected to the circuit ready to meet any demand which may occur during an emergency shut down, without depending upon the operation of any switching apparatus or any other attention.

A battery installation designed exclusively for control bus protection and operation is extremely simple. It usually consists of 60 cells for a nominal bus potential of 125 v. The actual voltage is usually held at an average of approximately 129 v. in order to maintain proper floating conditions. At this voltage the battery receives just enough trickle charge current to keep it constantly fully charged. After an emergency discharge the bus voltage may be raised sufficiently to recharge the battery within a reasonable length of time without exceeding the maximum voltage for which the control apparatus and signal lights are designed. It is usually permissible to increase the bus voltage up to a maximum of 140 v., and this will provide for charging the battery after an emergency discharge. Experience has proved that if proper floating voltage is maintained, periodic equalizing charges may be dispensed with.

Under normal conditions the generator is kept constantly running and connected to the bus, delivering enough current to supply the steady load of the signal lamps plus the necessary trickle charge current for the battery. The generator should be designed with a decidedly drooping characteristic in order to throw on the battery the greater part of the excessive demand when oil circuit breakers are operated.

Battery Designs

In designing a battery for oil switch service three principal points must be considered—

(1) The number of cells.
(2) Capacity of cells.
(3) Details of cell design.

As stated above, the number of cells used for a nominal 125-v. bus is usually 60. The number of cells being fixed, it is necessary to provide a cell of sufficient capacity to deliver the required output for oil circuit-breaker operation, without permitting the voltage to fall below the allowable minimum. Present practice fixes this minimum voltage at 105 v. at the battery terminals, thus calling for a minimum cell voltage of 1.75. The capacity of the cell must, therefore, be such as to furnish the maximum demand for the oil circuit-breaker service without dropping below 1.75 per cell. The ratings of control bus batteries as given in the manufacturers' catalogue are based on these requirements. Where only the momentary demand of the oil circuit breakers is considered, the one-minute rate of the battery to the specified final voltage is used. If, however, a certain amount of emergency lighting is to be provided for, sufficient battery capacity must be added to take care of this, and if the same battery is to be used for both purposes, the minimum voltage at the end of the emergency discharge is fixed by the oil circuit-breaker requirements. The battery capacity is usually given on the basis of the rating per positive plate and where the battery is to be used both for oil circuit-breaker operation and for emergency lighting or other continuous emergency discharge, the number of positive plates required for each kind of service may be figured, and these results added to determine the total number of positive plates per cell. In each case, however, the capacity to a final voltage of 1.75 must be used where this limit is fixed by the requirements of the oil circuit-breaker service.

Where a single battery is installed to take care of not only the oil circuit-breaker operation but various other emergency loads, and these loads are always connected

to the direct-current service bus and are supplied by a direct-current generator, it may not be permissible to increase the bus voltage appreciably, as some of the auxiliary apparatus may not be designed for such high voltage. In such case a number of end cells may be provided at one end of the battery with a suitable end cell switch, these end cells being cut out of circuit while the main battery is being charged directly from the bus. A booster or high voltage generator must then be installed for charging the end cells. In some cases where these conditions obtain, instead of providing end cell control, duplicate batteries are installed, both of which are normally floating on the control bus. When it is necessary to charge one of these batteries from a higher voltage,

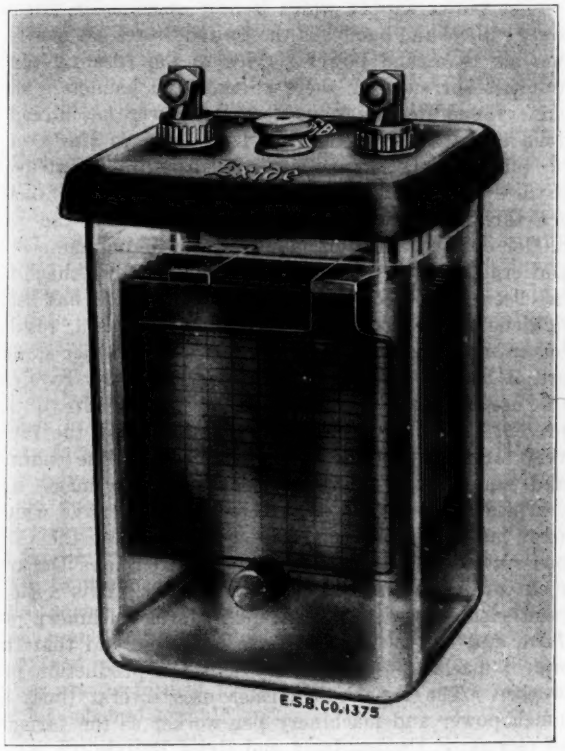


FIG. 3. A SEALED-IN CELL FOR CONTROL OF BUS SERVICE IN POWER PLANTS

it is disconnected from the bus and connected to a special charging circuit for which a high voltage generator or booster is provided. In one recent power house installation duplicate batteries are provided as above for the service bus, to which the station lighting and auxiliaries are connected, and a separate battery is provided for control bus service.

Cell Design

The details of cell design for these house service batteries depends upon the size of the battery and its location. Batteries of considerable capacity are installed in lead-lined tanks or up to a certain size in open glass jars. Such batteries are usually installed in separate battery rooms provided with good facilities for ventilation. Where the capacity is not too great and it is desired to install the cells in the same space with other apparatus instead of providing a separate battery room, the sealed-in cell can be furnished. These batteries are installed either in rubber jars assembled in wood crates in a semi-portable form or in glass jars with sealed glass covers. Such cells may be delivered filled with electrolyte and charged, ready for service as soon as they are connected up. The filling vents in the covers are provided with vent plugs of the spray-trap design for effectually preventing the escape of acid spray, so that it is perfectly safe to install these batteries wherever convenient without danger of corrosion to metallic objects in the vicinity. Where the capacity requirements do not exceed the limits for which a glass jar cell can be furnished, such a cell is preferable to the rubber jar assembly, on account of the facility of inspection.

Operating requirements for these batteries are exceedingly simple. To obtain satisfactory results two points must be watched. First, the level of the electrolyte in the cells must be kept above the tops of the plates by the addition of pure water from time to time. Second, the voltage maintained across the battery terminals should be kept at the proper floating value. If this average voltage is below the correct value, the battery will gradually discharge and its full capacity will not be available for emergency. If the floating voltage is too high, excessive charging current will flow continuously, which will shorten the life of the plates. It is desirable to keep this average floating voltage between the limits of 2.1 and 2.2 per cell.

The Power House Battery must be considered as a form of insurance and like other items of this kind, whether it be an accident policy or a lightning arrester, the justification for the expenditure cannot be based on a definite determination of the dollars and cents return on the investment involved; nor is it more logical to wait until emergencies actually occur in order to judge of the importance of protection, than it would be to wait for a fire to occur before taking out an insurance policy. One interruption may cost far more than the whole investment required to prevent it.

Sediment in Storage Batteries

During service, small particles drop from the plates and accumulate on the bottom of the cells. This sediment should be carefully watched, especially on the newer plates where it accumulates most rapidly, and should never be allowed to touch the bottom of the plates and thus short circuit them. If there is any free space at the end of the cells, the sediment can be raked from under the plates and then scooped up with a wooden ladle or other non-metallic device. If this method is impracticable, the electrolyte, after the battery has been fully charged, should be drawn off into clean containing vessels; the cells should then be thoroughly washed with water until all of the sediment is removed, and the electrolyte should be replaced at once before the plates have had a chance to become dry.

In addition to the electrolyte withdrawn, new electrolyte must be added to fill the space left by the removal of the sediment; the new electrolyte should be of 1.3 or 1.4 sp. gr. in order to counteract the effect of the water absorbed by the plates while being washed. If at any time any impurities, especially any metal other than lead or any acid other than sulphuric acid, gets into a cell, the electrolyte should be emptied at once and the cells thoroughly washed and filled with pure electrolyte.

Power Service to Rural Communities*

NOTHING WILL BE OF GREATER HELP TO THE AMERICAN FARMER IN LESSENING HIS LABORS THAN A UNIVERSAL USE OF ELECTRICITY. BY G. C. NEFF†

POWER SUPPLY has always played an important part in the development of our country. The early pioneers recognized the value of adequate power supply to a community. In those days the location of water power sites on small streams many times determined the location of new settlements. The small community fortunate enough to have a water power with which to operate the grist mill and local factory was envied by all other communities not so fortunate. The grist mill or factory drew business to the village from great distances and this caused such communities to develop, grow and prosper and many of them grew into thriving cities. As these communities grew, the local water powers did not often have sufficient capacity to meet the demands for power and it was necessary to supply some power by steam engines which in the early days were, of course, not very efficient.

The great improvement in the steam engine, followed by the development of the steam turbine and later the development of the local electric public utility, made it possible to supply power in the larger cities at a much lower cost than was possible in the small cities and villages. This condition helped materially to bring about a large industrial development in the large cities and often this was done at the expense of the small communities where an adequate amount of low cost power was not available. During this period many thriving small communities of the early days were abandoned, others decreased in population and still others barely held their own.

Then began the great expansion program of the public utilities, whereby large efficient generation stations were built and connected by transmission lines first to the larger cities, later to the smaller cities, and recently to the small villages. As a result of this development and expansion by the public utilities, power at relatively low cost is being supplied to a very large per cent of the small cities and villages of the United States and because these small communities now have an adequate power supply and are again in a position to bid for new factories and properly take care of industries now located within their boundaries, they should experience a very prosperous growth.

With present day electric service the small community has a great deal to offer to industry and to labor. With 24-hr. electric service, anyone living in the small community can have a home which compares favorably with the city home. Gas service may not be available, but cooking can be done electrically. Water supply from water mains may be lacking, but standard equipment at reasonable cost electrically operated will automatically supply the water in the bathroom, kitchen, laundry, or any other part of the house. Electric lights are just as attractive and can be made just as decorative in the small community home as in the city home. The electric street lighting, which is often of the decorative type, adds materially to the beauty of the small community and makes that community a much safer place in which to live. The advantages of lower cost of homes, lower cost of living, lack of congestion, availability of land for garden purposes, fresh air of the country, easily make the home in the small community more desirable for the average working man and his family than a home in the city. So situated, he can afford to work for smaller wages and at the same time he and his family can live with greater comfort and economy and be more truly contented. This means a great deal not only to the laborer but to the industry which employs him.

The power supply which is now available in almost every village and hamlet in the United States has made it possible to extend power service to the farming communities surrounding these villages and hamlets. Machinery operated by some form of power has already done a great deal for the American farmer. The use of the plow and the harrow is surely an improvement over the hoe or the crooked stick pulled by oxen. The modern threshing machine has replaced the flail and the binder does the work of many men swinging the sickle and cradle. Every time a new practical farm machine has been developed, the burden of farm work has been lightened and production per worker increased, resulting in increased income per worker and a higher standard of living. The use of machinery naturally requires the use of power in some form or other. Up to the present time this power has been supplied on the farm very largely by horses, steam engines, gasoline engines and windmills. The American farmer today makes liberal use of power and machinery. The extent to which farm machinery is used varies a great deal in the various states. A recent survey by United States Department of Agriculture discloses that there exists a close relationship between investment in farm machinery per farm and net income per farm operator, and that the use of machinery greatly increases the production per worker. The American farmer uses several times as much power and machinery per worker as the farmers of Germany, France, Italy and Great Britain.

USE OF POWER INCREASES STANDARD OF LIVING

Due to this greater use of power by the American farmer, it is possible to maintain higher production and higher income per worker and this makes for a higher standard of living on the American farm than is possible in the foreign countries mentioned above. So, if we would increase the standard of living of the American farmer, it is necessary to make it possible for him further to use power and machinery. It is believed this may best be brought about through a more diversified use of electric power.

When the steam engine was adapted to commerce on the high seas, it revolutionized transportation on the water. When the steam engine was first adapted to the steam locomotive, transportation on land was revolutionized. When electric drive was put into the factory, in the place of the old steam engine with its line shafts and belts, the manufacturing industry was revolutionized. In fact, wherever any new form of power has been introduced into any industry, it has revolutionized that industry. Furthermore, the introduction of a new

*A paper delivered before the Midwest Power Conference held in Chicago, Jan. 27, 1926.

†Vice President, Wisconsin Power and Light Co. and Chairman of the Rural Service Committee of the N.E.L.A.

form of power to an industry has, as a rule, greatly benefited that industry. No one will contend that the steam boat is not an improvement over the sailing vessel; that the steam locomotive is not an improvement over the stage coach; and that the electrically equipped factory of today is not an improvement over the steam-driven factory of a few years ago. We can safely predict that proper introduction of electric power to agriculture will greatly improve that industry and will be one of the principal means of increasing the prosperity of farmers and raising the standard of living conditions on the American farm.

Advantages of Electric Lighting

In addition to the advantages gained from the use of electric power, electric light will also play an important part in farm life. Imagine, if you will, a boy coming home with a team of horses at six o'clock on a winter night. When he opens and passes through the barn door, he steps into absolute blackness,—so black he cannot see the horse his hand touches. He must either tramp to the house, light a lantern, and return with it or he must unharness and care for his team by a sense of touch and his knowledge of the barn arrangement. At the end of a day of hard work he will usually choose to stumble about in the blackness until he finally blunders through the job. This is not fiction, it is just a plain statement of what actually occurs on almost every farm. Hundreds of thousands of farm boys will grope in the dark for harness hooks tonight.

Just imagine milking in the average farm barn, which has none of the advantages of the specialized dairy farms where sanitation rules. A long line of cows is barely visible in the light of an oil lantern. There is no possibility of noting sanitary conditions or of improving them. In the dimness, filth cannot be avoided but must be stoically accepted. It is not a fitting place to produce an easily tainted food. With proper light, such as can be had when electric service is available, much unpleasantness is eliminated, cleaner and more sanitary surroundings are maintained, and the duties are performed by the farmer with more respect for his job and himself.

Only Four Per Cent of Farmers Have Electric Service

A farmer has no chance to cope with marauders at night. The dog may bark and the chickens may squawk, but before the farmer can investigate the disturbance, he must find in the dark a lantern and matches. When he sallies forth he is at the center of a bright spot visible for a mile but he can see nothing 100 ft. away. Lighting the yard protects his property, adds to his peace of mind, makes his surroundings more attractive and aids him to do chores faster, more easily and more safely.

There are approximately 6½ million farms in the United States and less than 250,000 or less than four per cent now enjoy central station service. From this it might appear that practically nothing has been done by the utility companies in extending electric service to the farms. To correct this impression, consider the following statements. In that part of the United States lying between the Allegheny Mountains on the east and the Rocky Mountains on the west are approximately 100,000 farms receiving central station service.

On the average three farms can be served from one mile of rural line. Therefore, there are located in this middle section of the United States approximately 33,000 mi. of rural lines.

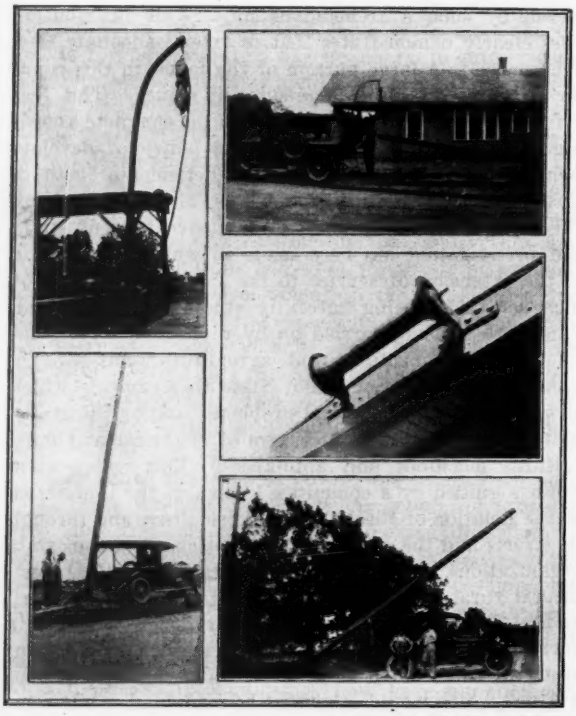
In the more thickly settled region of the Atlantic coast and in the region along the Pacific coast, where electric service is used on farms for irrigation purposes, the number of farmers receiving electric service from central station lines is about equal to the number served in the great middle part of this country. The miles of line on the coast regions which are devoted to rural electric service add greatly to the mileage just described. This shows that an exceedingly large amount of rural lines have been built, that huge amounts of money have been spent, and that an appreciable start has been made in this greatly needed development. The fact that less than four per cent of the farms in this country are served by such a tremendous mileage of distribution lines clearly demonstrates that to extend adequate electric service to a large portion of the farms in this country is a task involving huge sums of money. This fact is fully appreciated and so it is with the complete knowledge that the adoption of a wrong policy of development would result in losses, very detrimental both to agriculture and the utility industry, and also seriously affect other industries that an extensive plan of study and investigation has been made in which every angle of the extension of service to the farm and the use of such service is being carefully studied and analyzed. This work is being carried on by representatives of agricultural organizations and agricultural colleges; by agencies of the National and State Governments which have to do with agricultural problems; and by the utility industry and the manufacturers of electrical and agricultural machines and appliances. This co-operative work is guided by a committee known as the Committee on the Relation of Electricity to Agriculture and through its efforts and the excellent co-operation of various state organizations, there have been established 17 experimental rural lines in 17 different states. These experimental lines really form field laboratories in which to carry on the study of rural electric service. By a joint study of this kind it is believed many mistakes will be avoided which would otherwise be made and, while some mistakes will probably be made, even with the precautions taken, it is believed the major mistakes will be prevented. In the meantime, rural electric service development is going ahead as is illustrated by the figures which I have given. Thousands of farms are being connected every month and the rate of increase in connections is growing each year.

The information being gathered from the experimental lines is helping and will continue to help, speed up the growth of rural electric service, because from this information we learn how better to apply electric service to agricultural operations. The major part of the rural electric development is ahead of us and much depends on how this development proceeds. A serious effort is being made to guide the development work along sound economic lines, building step by step on facts now known and on new facts as fast as they are proven in the field laboratories now in active operation. Only in this way can we expect to make this gigantic development permanent, productive, successful and fair to everybody concerned.

A Novel Method of Erecting Poles

By H. J. Achee

IN CONNECTION with the construction of pole lines on our distribution system, we have developed a novel method of erecting poles by means of one of our ¾-T. Dodge trucks. The method used is self-evident from the accompanying illustrations. As will be noted, we have fitted an iron roller to the top of our truck, the top first having been reinforced by braces of channel iron and an iron plate bolted to the back of the top. The roller consists of a 2-in. iron pipe, 12 in long, on each end of which is welded a 6 in. flange with the bevel side towards the center of the roller. The flanges were made from the outer casings of



VIEW SHOWING METHOD OF ERECTING POLES WITH AUTO TRUCK

an old Ford Universal joint. An iron rod ½ in. in diameter was passed through the center of this pipe extending 2 in. beyond each end of the roller. The roller was then filled with molten lead which, when solidified, served as a bearing surface between the roller and the iron rod. The whole equipment weighs about 25 lb. and, as it always remains stationary on the truck, it in no way interferes with the use of the truck for other purposes than setting poles.

In addition to this roller, a crane was made to lift the poles from the ground onto the roller. This crane is made out of a 2-in. galvanized iron pipe bent at the top so as to be off center 29 in., which is sufficient to hold the pole exactly over the center of the roller. The crane is 8 ft. long from end to end and is bolted to the truck at the lower end by means of a U-shaped clamp. It is further secured in a socket made from a piece of 2½-in. pipe, 32-in. long, which is bolted to one of the upright pieces at the rear of truck.

In using this equipment a short wire sling made from a piece of stranded wire raises the pole from the ground up to the roller. When in this position its lower end is spotted reasonably near the hole in which it is to stand and, as the truck is moved backwards towards the hole, the pole is gradually raised to a vertical position. Two men can easily operate this equipment and, under ordinary conditions, can set up 32 poles per 8-hr. day.

If necessary, the same equipment can be used for taking up the poles, by digging out the dirt on one side of the bottom of the pole and lifting it out by means of the crane and tackle. The pole is lifted up to a height of about 2 ft. and the truck driven forward until the pole rests on the roller previously described. By removing the tackle and running the truck forward, the pole is gradually lowered to the ground.

Starting and Controlling Induction Motors

By Philip G. Bernholz

OF ALL ELECTRIC drives the simple squirrel cage induction motor is by far the most common and it may be of interest to many not entirely familiar with electric machinery to know more about controlling this type of motor. It is the writer's experience around factories that most people believe that a starter is used or is necessary to protect the motor while it is being started up. They would prefer to stand at a distance if a fifty or a hundred horsepower motor were to be connected directly to full line voltage at standstill. Yet, in most cases, this would not harm the motor. The ordinary induction motor is capable of withstanding almost any abuse except overheating. Motors of several thousand horsepower running full speed have been switched over in reverse rotation on full line voltage. A starter is, therefore, used not merely to protect the motor in getting it up to speed as would be the case with nearly all other types of motors but to prevent disturbances on the electric system by limiting the current taken from the line and to protect the machinery coupled or belted to the motor. Of course, it is a considerable strain on the motor winding but nothing that should hurt any good motor. On account of the large current that such motors take at starting, power companies do not permit over a certain size motor being started directly from the line, which then means that some kind of a starter has to be used. Most applications of fair sized motors do not permit the rapid acceleration that full line voltage would give, so general practice is to provide all such motors above about 5 hp. with some sort of a starter.

While the starter is not so important from the standpoint of protecting the motor in getting it started, it is a mistake to pick out the cheapest starter that will start the motor. A motor generally does but one thing and some makes of starters will do but one thing but a good starter should do several things. For example, some starters will start the motor only at a reduced voltage, giving no protection while starting or after the motor is started and even this operation is not carried out successfully. If the changing over from start to

running is not quick, there is an instant rush of current due to the motor dropping back a half cycle to opposite polarity which causes greater strain in the machine and on the line, as has been shown by oscillograph records, than if the motor had been thrown to full line voltage while standing still. Of course, this disturbance passes in only one or two cycles but it produces currents seven to eight times the full rating of the motor while the impedance of the same motor standing still would allow only about four times full load current. It is for this reason that all good starters have a mechanism that will not permit changing from start to running unless it is done as fast as possible.

A good starter, on the other hand, will bring the motor up to speed on reduced voltage, connects it to the line by a motion too quick to permit the motor to drop in speed even if loaded. It is ready to release the motor automatically from the line whether it starts or not or if one line is open or any other trouble before any harm can come to the motor. After the motor is started, it protects the motor at all times against overload that would harm the motor as well as low voltage or the power going off. All except the starting protection is found in all good hand starters and large sizes may have that but this is not the case with small starters. Modern automatic starters usually have all the protective features enumerated, so that it is practically impossible to abuse the motor regardless of what is wrong or who tries to start it.

If the motor is stalled or the load is such that the motor cannot attain full speed, a careless operator will often try to force the motor into action by holding the handle. In such a circumstance a motor may groan along for a time but it will soon overheat and cause damage to the insulation. This same operator with an automatic starter could not keep the motor on the line long enough to injure it even if he repeated the operation several times. Few operators of a hand operated starter wait until the motor is fully up to speed before throwing over to the running position. This causes unnecessary burning at the contacts as well as defeating part of the idea for which the starter is used. Automatic starters always operate at the right time when changing over and the operation is so fast that the motor has no time to drop in speed or cause burning at the contacts. In fact, automatic starters have operated over one hundred thousand times on motors without changing any contacts.

Hot-Water Heating Systems Use Exhaust Steam

DISCUSSION OF HOW EXHAUST STEAM MAY BE USED, ADVANTAGE OF HOT WATER AS A HEATING MEDIUM AND DESCRIPTION OF HEATERS

HEATING SYSTEMS, to be ready for use in November, must be planned and installed in summer. One of the best types of heating systems for comfort and health is the hot-water heating system. It fits in especially well with large exhaust steam installations.

Over the greater part of the United States it is necessary to use some heat in dwellings and shops for from six to eight months of the year. Hotels, hospitals, institutions, office buildings and large shops in which power demands are light, can frequently make use of all of their exhaust steam within their own walls during the greater part of the heating season. Shops requiring a large amount of power can often dispose of their exhaust steam to heat surrounding buildings, either selling the heat outright, or using it to heat employes' homes and other company owned buildings.

With hot-water heating systems, says Wheeler News, some vacuum may be carried on the prime mover at all times except during the most severe weather. In this way the utmost power is obtained from the steam before it is used for heating purposes. The saving by running with a partial vacuum during warm weather is apparent. Thus, if the outside temperature is 40 deg., the temperature in the hot water system can be as low as 145 deg. and the corresponding water rate of a turbine 28 lb. per kw-hr. If the outside temperature is 0 deg., the circulating water must be 200 deg. and the water rate of a small turbine may be 40 lb. per kw-hr. The average outside temperature for the entire heating season, including all the days from when heat is turned on in the fall to when it is turned off in the spring, will average nearer 40 deg. than 0 deg.

The same heater can often be designed to act as a heater in the winter and a condenser in the summer. Two heater-condensers are installed in the plant of the Comstock Cheney Co., in Ivorydale, Conn. Used as a heater, each of the two 312-sq. ft. units will heat 600 gal. of water from 175 to 195 deg. F. when supplied with steam at 2 lb. gage. Operating as a condenser, each unit will condense 4000 lb. of steam per hour at 26-in. vacuum when supplied with 350 gal. minimum of water at 70 deg. F. In this way the advantages of condensing operation are obtained throughout the summer months when heating is not needed and the capital investment for heaters put to use during the entire twelve months.

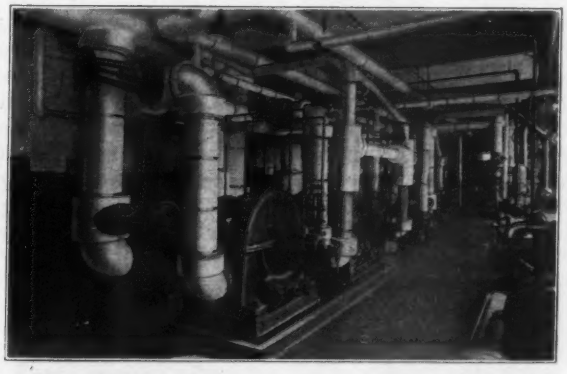


FIG. 1. TURBINE-DRIVEN CENTRIFUGAL PUMP FOR CIRCULATING HOT WATER IN HEATING SYSTEM OF REMINGTON ARMS CO.

Where the buildings to be heated are at a considerable distance from the power plant, the hot-water heating system has advantages over a steam system, in that no additional back pressure is imposed upon the engine

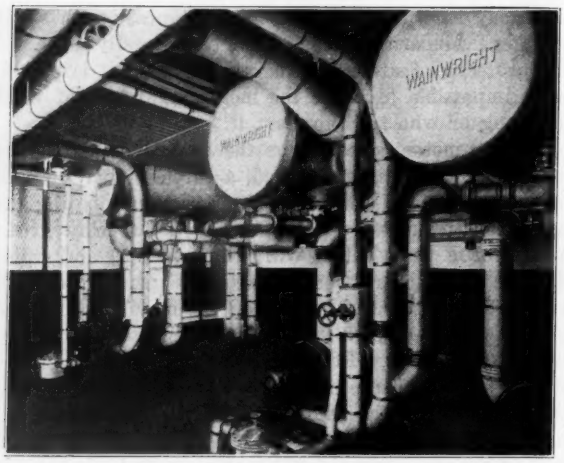


FIG. 2. HEATERS AND PUMPS SERVING PLANT OF MORSE TWIST DRILL CO.

or turbine and comparatively small pipes will transport the hot water without excessive pressure drop. In steam-heating systems in which the buildings to be heated are widely scattered, it is often necessary to waste the condensed water, due to the difficulty of piping it back to the plant, thus depriving the boilers of a source of clean feed water. In a hot-water heating system, the condensate is, of course, available for boiler feed water.

Hot water provides the most flexible and healthful source of heat. The temperature and quantity of the outgoing hot water may readily be regulated at a central point for each variation in outside weather conditions. Each building heated can always be made comfortable, neither too hot nor too cold, in any weather. A different schedule will, of course, be adopted for different buildings, according to the construction of the buildings, the location, the temperature desired in the rooms, etc. The accompanying table shows the temperatures adopted by the Columbus Railway and Light Company as reported by W. A. Wolls, N. D. H. A. In this installation the temperature is further regulated according to the wind velocity and whether the outside temperature is rising or falling. Lower temperatures can be used during bright sunshiny days. Dwellings or buildings used only in the daytime may be allowed to become cooler during the night.

Automatic control from a central point results in large savings, reducing the temptation for the occupants of rooms to open the windows to cool off the rooms, rather than regulate the supply of heat. It is necessary to use the individual radiator regulating valves only when it is desired to reduce the temperature of the room from that predetermined at the central heating plant. The large heat storage capacity of the hot water in the pipes and radiators prevents a too-rapid decrease in temperature, if it should be necessary to turn off the source of heat for any reason. The heat radiated from a hot-water radiator is mild and equable because of the lower temperatures employed. The air in the neighborhood of the heater is not scorched or overheated.

WATER TEMPERATURE FOR STILL WEATHER CONDITIONS, AS USED BY COLUMBUS RAILWAY & LIGHT CO. ON HEATING SYSTEM

Outside Temp.	Supply Temp.	Outside Temp.	Supply Temp.	Outside Temp.	Supply Temp.	Outside Temp.	Supply Temp.
+68	106	+42	147	+18	187	— 6	218
+66	112	+40	150	+16	189	— 8	221
+64	117	+38	154	+14	191	—10	224
+62	121	+36	157	+12	194	—12	226
+60	125	+34	159	+10	196	—14	229
+58	128	+32	162	+ 8	198	—16	232
+56	131	+30	165	+ 6	201	—18	235
+54	133	+28	170	+ 4	204	—20	237
+52	135	+26	175	+ 2	207	—22	240
+50	137	+24	178	0	210	—24	243
+48	139	+22	180	— 2	212	—26	246
+46	141	+20	184	— 4	215	—28	249
+44	144						

With falling outside temperature and wind 12 miles per hour, 5 degrees are added.
With falling outside temperature and wind 18 miles per hour, 10 degrees are added.

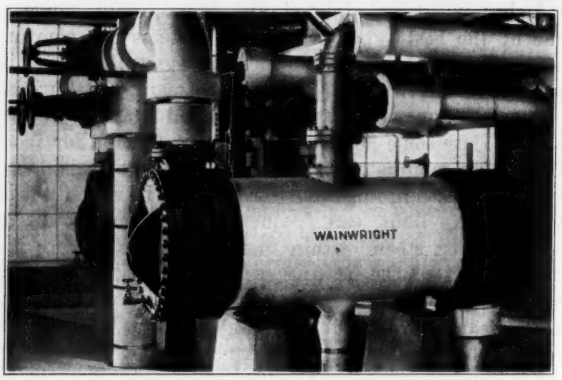


FIG. 4. TWO SPECIAL 500-SQ. FT. HEATERS HAVE STEEL SHELLS, OPERATING AT 65 LB. BUT DESIGNED FOR 125 LB.

FIG. 3. IN HEATING SYSTEM OF CENTRAL TERMINAL DEVELOPMENT, NEW YORK, WHICH INCLUDES BILTMORE HOTEL, 6000-G.P.M. HEATERS RAISE WATER FROM 140 TO 180 DEG. WITH STEAM AT 5 LB. GAGE

HEATERS FOR THE HOT-WATER HEATING SYSTEMS

Heaters are constructed for vacuum or pressure operation. The water to be heated flows through tubes and heating steam surrounds them. High efficiency is obtained by the use of high water velocities through the tubes and good steam distribution with ample venting on the outside of the tubes. The water makes one or more passes through the tubes, according to the nature of the service. Short, straight tubes are employed, which are easily cleaned or replaced. Heaters may be designed to give as low as from 2 to 5 deg. terminal difference between the exhaust steam and the hot water.

Isometric Pipe Layouts Eliminate Many Errors

By Laying Out Piping in Isometric Projection on Blackboard or on Isometric Paper, Draftsman Can Help Himself and the Workman. By V. L. Sherman

UNNECESSARY EXPENSE in engineering work often originates in the drafting room; especially is this the case in laying out piping. Engineering students —and draftsmen, too—erupt many odd pipe drawings. Lacking real practical experience, they often cheat unintentionally on dimensions, mix up the planes of projection and generally doctor the drawing for looks. Of course, in large drafting rooms, where drawings are checked before being used, the man who does these things either mends his ways or loses his job. But there are many occasions, especially in power plant work, where errors in piping drawings are not discovered until the pipe-fitters start to erect the pipe.

FIG. 1. FULL SIZE ISOMETRIC PIPE LAYOUT ON BLACKBOARD HELPS THE BEGINNER

One way of preventing many of the errors is by the use of isometric drawing in laying out pipe drawings, combined if desired with the regular orthographic projection. This method has been used with great success in teaching students of engineering. For the beginner, isometric piping layouts in full size on the blackboard, as shown in Fig. 1, form the finest of preliminary training. He is forced to give attention to the corners and to respect obstructions. Standing at the board with chalk and string and the "stop—look—listen" sign (shown in the lower left-hand corner of Fig. 1) he can go along full size and visualize the work. After he has the idea well in mind, he can make the usual type of orthographic projection with much more intelligence.

The same idea can be carried out on isometric paper, as shown in Fig. 2. This can be used for free-hand sketching. The student either makes his orthographic projections first and then checks them by the isometric sketch or he can reverse the procedure and make the isometric sketch first. The free-hand work is rapid and accurate; it can be single or double line and to any reasonable scale.

At the present time, many industrial plants are using isometric shop drawings either alone or in conjunction with the usual orthographic views. In addition to the advantages from the draftsman's standpoint, the isometric drawing is of great assistance to the workman, to whom, in many cases, the average working drawing

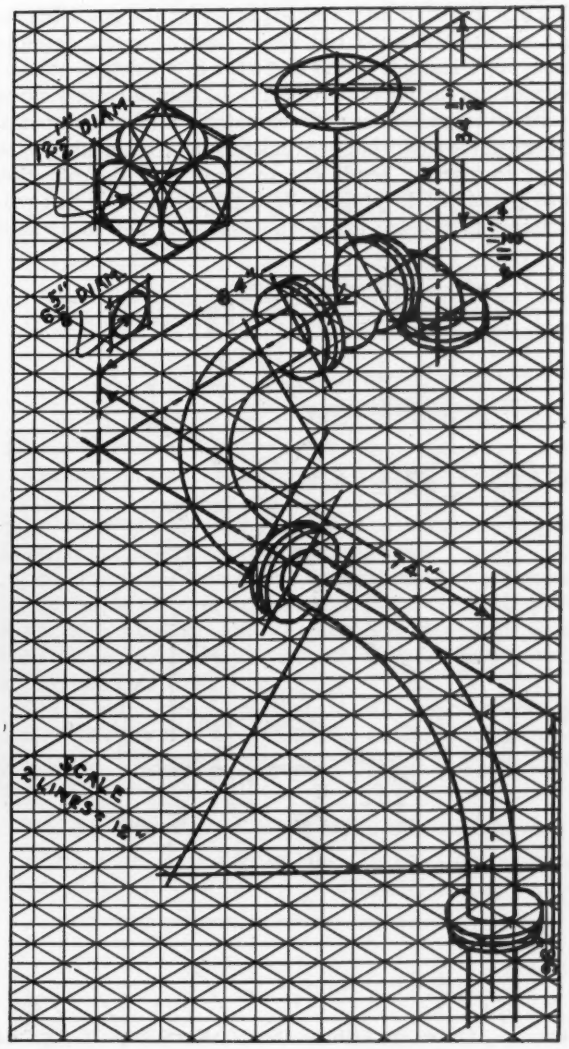


FIG. 2. ISOMETRIC PIPE LAYOUT, DRAWN FREE-HAND ON ISOMETRIC PAPER, IS USEFUL FOR CHECKING ORTHOGRAPHIC PROJECTIONS

means little. To the power plant engineer, this method of making and using isometric pipe layouts should prove a great saver of time and labor.

EYE PROTECTION for workers at the charging furnaces in the plant of the Timken Roller Bearing Co., Canton, Ohio, is provided by a pane of safety glass 18 by 24 in. and ¼ in. thick. Blue glass similar to that used for melters' goggles, is used in a wooden frame and 4 in. in front of it is another frame covered with copper screen to break the heat and protect the glass.—National Safety News.

DO NOT ASSUME that your pressure or vacuum gages never lie; test them periodically.

Hydraulic Maintenance at Holtwood

DETAILS OF 15-YR. PROGRESS AND DEVELOPMENT OF A MODERN HYDROELECTRIC STATION. BY T. C. STABLEY*

PROCEDURE and methods of hydraulic maintenance in the Holtwood 150,000-hp. hydro-electric development were started, in the first year of operation, to take care of the earlier types of vertical, double runner units with a large number of operating mechanism parts. These parts could not conveniently and economically be kept in perfect condition, so wear and deterioration was permitted to progress to a point where it was economical to replace the worn parts, but not to a point

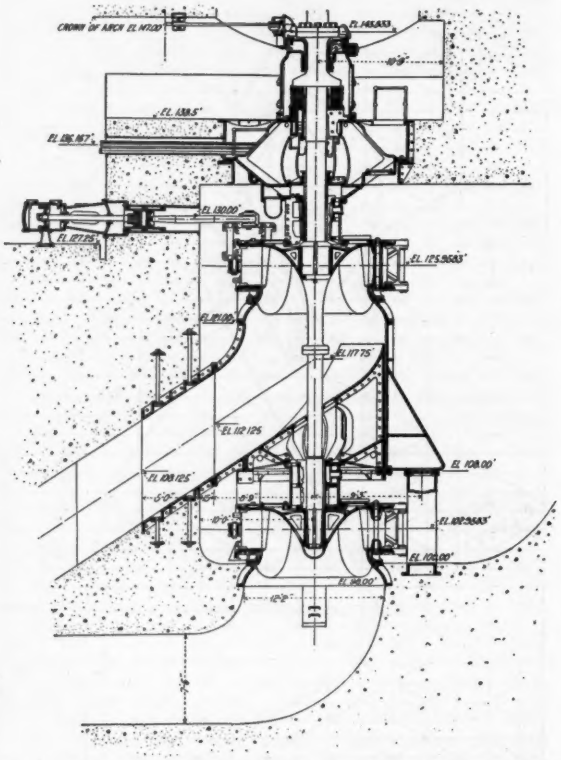


FIG. 1. SHOWING THE GENERAL ARRANGEMENT OF THE DOUBLE RUNNER UNITS

which would interfere with the output of the unit or endanger continued operation.

Corrosion caused by the acid condition of the water, wear from abnormal quantities of silt and sand at certain periods of the year, mechanical failures due to casting defects, corrosion or outside causes, and pitting or cavitation of the turbine runners are the four conditions affecting maintenance.

Installed by I. P. Morris Co., the plant consists of seven vertical, double runner units with submerged operating mechanism similar to Fig. 1, and three single runner units with the control mechanism located on top of the turbine. Units Nos. 9 and 10, installed in 1923, are similar to Fig. 2, the central cone of the Moody draft tube extending to the runner cap.

*Chief Operator of Holtwood Plant, Pennsylvania Water & Power Co. Abstract of a paper presented at the Baltimore Section of the A. S. M. E., November 21, 1925, and appearing in the April, 1926 issue of Mechanical Engineering.

Commercial operation was started in October, 1910 and trouble from corrosion became evident in the first unit after a few months of service. Movement of the operating mechanism became extremely sluggish, requiring the governor fluid pressure to be gradually raised from 125 to 250 lb. over a period of approximately a year and a half.

MODIFICATIONS MADE IN OPERATING MECHANISM

Certain modifications in the operating mechanism were incorporated in the later units, and by replacements in the old units, difficulties due to corrosion were corrected by the following five methods:

1. By attaching brass liners to the operating and guide rings, "Demaxine" was later substituted for brass, tripling the life of the liners.
2. By inserting brass bushings in both pin holes of the vane links.
3. By reducing the bearing surface of the fulcrum pin to a minimum, having contact with the vanes at top and bottom only.
4. By making provisions to force grease through the fulcrum pin, and fill with the recessed space between fulcrum pin and vane bore at five-year periods with "Hydraulic Lubricating and Coating Compound," a heavy semi-fluid adhesive grease.
5. By attaching bushings to fulcrum pins and into the bore of the vanes at both top and bottom.

Due to the fine silt carried by the water, steel pins in the operating mechanism wore rapidly so that in two years the vanes would not fully open or close. Monel metal was substituted for steel and proved to be satisfactory only for the 160 small pins. "Ascoloy," an electric furnace product, is now used for the 10 large pins of the operating rings and provisions made to lubricate them with heavy oil.

These changes resulted in decreasing the force necessary to move the operating mechanism of the turbines, as indicated below:

Year	Condition of mechanism	Force to move operating mechanism at 50% gate opening, lb.
1912	Badly corroded	65,000
1918	Good condition. Wearing parts provided with brass liners and bushings	13,700
1925	Good condition. "Demaxine" metal substituted for brass liners and other minor modifications	9,500

PAINT AND ENAMEL NOT ENTIRELY SUCCESSFUL

Experiments with paints and enamels on the submerged turbine castings and parts where the water impinges directly have not been entirely successful. On other turbine parts a mixture of two coats of red lead with equal parts of linseed oil and flexible compound have been found in a fairly good state of preservation at the end of 10 yr.

Lignum-vitae guide bearings are lubricated by water taken directly from the wheel pit so that silt causes both

the bearing and shaft sleeve to wear. The upper lignum-vitae bearing of the double runner units is replaced approximately every 12 yr., the enlargement being slightly more than $\frac{1}{32}$ in. The lower bearings wear $\frac{1}{8}$ in. in from 3 to 4 yr. The single bearing on No. 8 averages 18 months' service, while those with adjustable shoes used on Nos. 9 and 10 turbines give about 3 yr. service.

Experiments have been carried out with rubber guide bearings, the original installation being on one of the 1000-hp. exciter turbines. After a year's satisfactory service an installation was recently made on the 16,500-hp. single runner turbine. Although the merit of this type of bearing for large units is yet to be determined, it seems to offer a marked improvement over past practice and the increased life of the bearing should more than justify the increased cost.

Roller thrust bearings on the original units were not entirely successful, so a trial installation of one Kingsbury thrust bearing was made in 1912 and, after 2 yr. satisfactory service, the remaining roller bearings were replaced with Kingsburies as opportunity permitted. Measurements taken on one of the shoes of the first Kingsbury bearing showed a maximum wear of 0.0025 in. after 3½ yr. service and 0.005 in. after 13 yr. service. Power loss varies from 9 to 12 hp. as compared to 17 to 32 hp. for the roller bearing type.

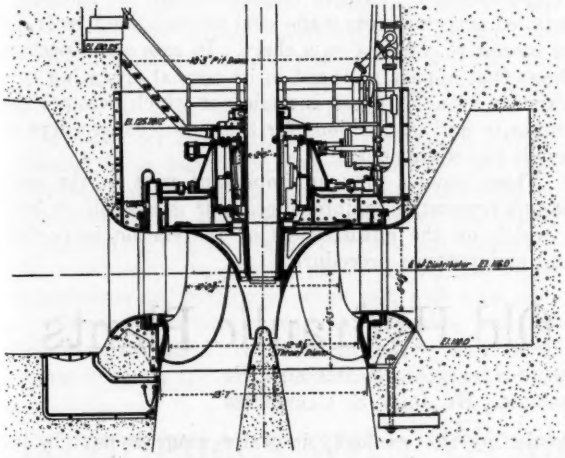


FIG. 2. GENERAL ARRANGEMENT OF A MODERN SINGLE RUNNER UNIT WITH THE MOODY DRAFT TUBE

Governor Mechanism Requires Few Changes

The entire governor mechanism is dismantled and cleaned yearly and replacements made if needed. Regulating and pilot valves were originally of composition bronze but after the increase in governor control pressure showed rapid wear. Monel metal was substituted, with a considerable increase in the life of these parts. Belt drives provided for the governor on the first five units were replaced by a gear drive through a horizontal shaft. Vibrations from the gearing are dampened by a set of four steel compression springs within a flexible coupling which are replaced about every 4 yr.

Figure 3 shows the periods when general repairs were made to the operating mechanism on No. 4 turbine. It is typical of all double runner units and indicates improvements in the maintenance methods by the lower frequency of general repair periods.

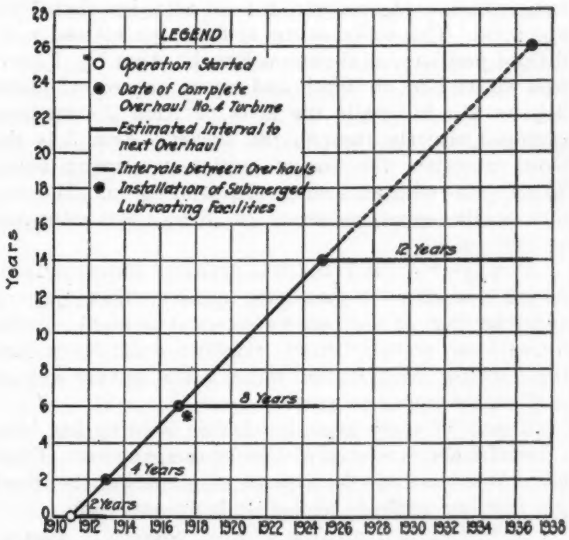


FIG. 3. INCREASING TIME INTERVAL BETWEEN PERIODS OF OVERHAUL SHOWS PROGRESS OF MAINTENANCE METHODS

Maintenance of single runner turbines is a comparatively simple problem and the wear on No. 8 unit, after 8 yr. of service, is small. Units Nos. 9 and 10 have been in service nearly 2 yr. with several replacements of the cast-iron links.

As a rule, failure to turbine or equipment rarely occurs and the time a unit is not available for service because of inspection, cleaning or repairs averages only about 5.2 per cent.

Pitting Confined to Four Well Defined Areas

Pitting or cavitation in the double runner units occurs chiefly in the upper runners and in the single

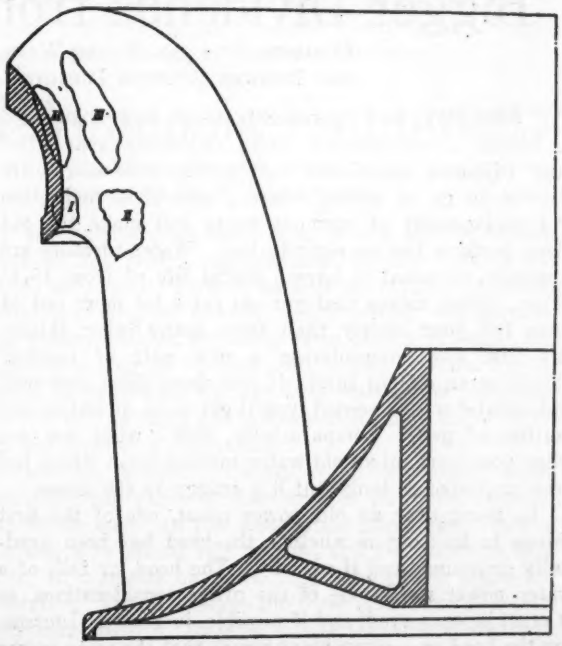


FIG. 4. AREAS AFFECTED BY PITTING ON THE UPPER RUNNER OF NO. 5 UNIT ARE WELL DEFINED

runner units evidences were noticed after less than 1 yr. operation. This action occurs at four separate and well-defined positions, as shown on Fig. 4. Area No. 1 averages about 2 in. in depth and covers an area of about 3½ by 4½ in., while the holes of Area 2 sometimes extended entirely through the bucket. Area 3 is the most extensive, the largest section measuring about 23 x 4½ in. with an average depth of ¾ in. The volume on the upper runner of No. 5 unit was estimated at 1026 cu. in.

Pitting of Areas 1 and 2 is probably caused by prolonged operation at part gate opening, where jets of water impinge on the bucket runners at an angle. Areas 3 and 4 are probably due to excessive draft heads during low flow when the tail-water is low as they appear only on the upper runners.

Repair of these areas by electric welding has been successful and is now carried on by company men. Costs given below include the expense of preparing the wheel pit, erecting scaffolds and other incidental costs.

	1924 Unit No. 4	1925 Unit No. 5
Total cost of job	$2,919.25	$2,439.20
Estimated volume of pitting, cu in.	979	1026
Welding metal used, lb.	505	596
Metal actually deposited, lb.	354	417
Time required for welding, hr.	1274	821
Cost per lb. of metal used, based on total cost of job	$5.78	$4.10
Cost per lb. of metal actually deposited on each runner, based on the total cost of the job	$8.27	$5.85

Litharge, Smooth-On, and cement have been experimented with but found unsuccessful. Type metal tried in several places was found in its original condition after one year's service.

Before repairs are made, the wheel pit is sterilized with live steam and while men are working, fresh air is furnished by a blower. 32-volt electric circuits are used exclusively.

Governor System Fluid Treated With Barium Hydrate

In 1912 a central station governor control pumping system was installed and the pressure increased from 150 to 275 lb. Centrifugal pumps used for this service are reliable and require few repairs. Raw river water was originally taken directly from the forebay and the corrosive effect on the piping was considerable. One pound of barium hydrate for every 250 gal. of water is now used as a neutralizing agent with the result that few replacements have been necessary in the governor system piping, whereas other pipes carrying raw water have a comparatively short life whether galvanized or ungalvanized.

Complete maintenance and inspection instructions have been issued with detailed directions as to how the apparatus is to be inspected, what is to be looked for and the precautions to be observed. Charts show to whom the inspection is assigned, indicate the period of inspection, the date and initials of the inspector. Progress chart of hydraulic inspections covers all equipment except turbines. Turbine inspections call for numerous detailed measurements made semi-annually and recorded in successive columns on a chart. In case an inspection shows that apparatus is not in its normal operating condition, a trouble report is made out which becomes the authority and instructions for the maintenance corps to repair the equipment.

These reports play an important part in the company's preventive maintenance, as it is possible to keep a watch on the effectiveness of the station inspection and maintenance procedure.

Bigger Dividends from Old Hydraulic Plants

Cleaning Out the Water Ways, Lining Bearings and Dressing Up the Runner Buckets Improve Operation. By John S. Carpenter

IT REALLY is a downright shame how many old plants, after running along faithfully year after year (dimmed lights and soft music, professor), are allowed to go to pieces, when a periodical inspection and replacement of wornout parts will make the old plant perform like an eight in line. Water turbines are generally supposed to have a useful life of from 15 to 20 yr., which means that you do get a lot more out of them for your money than from many other things. It's just like embroidering a new pair of monkey glands on an old tin Lizzie, if you check them over well and rebuild where needed, you'll get miles of smiles and scuttles of pep. Comparatively, that's what you get when you overhaul an old water turbine plant which has been neglected so long that it's groggy in the knees.

In going over an old power plant, one of the first things to find out is whether the head has been gradually dropping, and if so, why. The head, or fall, of a water power site is one of the prime considerations, so it must be conserved, and if possible, increased. Increasing the head on a given plant means that the same power can be generated with proportionally less water and I would say that economy in water usage is next in importance after head.

Starting at the source, which is the forebay or head gates and trashracks, make a general cleanup and inspection. Note whether any of the rackbars have been bent by impact from floating logs, ice jams and trash. See that the water level, with the turbines running does not drop more than about 2 or 3 in. in going through the racks or gratings. This is lost head and should be kept down. If the bars are too close together, it will often pay to cut out every other bar, for there are few plants that will not stand at least 2 to 2.5 in. center to center. Often much of the trash such as planks, sticks, leaves and branches can be prevented from reaching the trashracks by the use of a log boom. This is merely a series of logs, 8 to 12 in. diameter, connected at the ends by short pieces of chain, the end logs anchored to shore or abutments. Sometimes the river current can be utilized to carry the accumulated trash away and so make manual cleaning unnecessary, by placing the log boom obliquely across the forebay.

Next, the canal or pipe line should be inspected and

cleaned out if needed. The things that are often found in neglected canals and flumes are both unprintable and beyond ordinary belief. In one case, the skeleton of a cow was found, thus clearing up the mysterious disappearance of Mrs. Murphy's "Katrinka." Large stones and sunken logs do not help the water to flow freely, and this is another place where some lost head may be regained. If found, leaks in steel pipes should be calked with babbit metal or else drilled out and plugged. Leaks in wooden flumes can often be cheaply repaired by nailing or bolting on wooden strips with rubber gaskets between the strip and the flume material. Pitch or tar are also useful to stop leaks.

When we get to the turbine, if possible, take out the runner and inspect it with extreme care. If the runner is not readily accessible, take the gates away so the buckets are in plain view. Note if any buckets are loose, or if holes are eaten through them on the discharge side. Holes can be welded shut and loose buckets can be welded fast again. Should the entrance edge of the runner be blunt or dug out the edges should be filed or ground sharp on the back of the vane—not on the front or working face. Make a metal templet having a 2-in. radius cut in it and use that to get the curve uniform. The edge should not be less than $\frac{3}{32}$ in. thick and rounded. Smooth up the surface of the vanes and chip off any rust growths, barnacles and the like. When down to a smooth surface, paint with two coats of red lead or hydraulic paint. Smooth runner surfaces and sharp vanes at the entrance mean more power and efficiency with the same water consumption.

Now look over the bearings. If they are of lignum vitae wood, it is more than merely probable that they will be found worn and the runner out of center in the turbine case. Step bearings may be worn one-sided; these can be trued up in a lathe, or if too bad, measured up for new ones. At present prices for lignum vitae, some engineers are putting in scrub oak, with good success. When the runner is ready to put back into the turbine case, see that it is placed central in the bore of the running joints and set up the trammeling screws in the bearings accordingly. Runners that are out of center often waste as much as 10 per cent water.

See that the gates work freely on their pivot pins without pins binding or working in the gates with too much lost motion. They can be cheaply bushed to size with brass pipe bushings if found to have too loose fits. Often one finds bearings for gate shafting with the babbit all gone. Using the shaft as a mandrel, pour a new lining and then re-aline all shafts and connections.

Draft Tube May Cause Turbine Vibration

Next in order is the draft tube. If this is of steel, see that the lower end is anchored with guy rods or cables so it does not vibrate. Much turbine vibration is due to draft tubes that are the exciting cause. For such a matter, often good turbines are given a black eye. If air leaks are located, a heavy coat of pitch will cure the trouble. It is more important to have an air tight draft tube than a tight pipe line, so far as the turbine is concerned. Check up all draft tube connections to the turbine case to see that the bolts are tight and gaskets holding the pressure.

One of those places often thought to be unimportant is the tailrace. As soon as the water gets out of the draft tube, many people think it does not matter if the discharge is choked up and the water seen foaming and dashing around. Nothing could be farther from the truth. A choked-up tailrace backs water up against the turbine and decreases its output as fast as if the forebay was lowered that much. So let us clean out all the boulders, weeds and growths, the dog houses and whatnot, and if possible widen or deepen the channel so there is a uniform passage away for the water. The standing level of the water can be as little as 6 in. above the highest part of the draft tube discharge, for the low water stage.

Checking up the oil pressure governors should be left for an expert. It does not pay to try experiments unless one is accustomed to the careful adjustments required and many a pipe line has blown up or collapsed because someone tried "to fix the governor."

Experiences with Welded Ammonia Equipment

Intermittent Refrigeration System First to Use Welded Vessels; Discussions of Some of Difficulties Encountered. By W. F. Schaphorst

IN THE NOV. 1 issue of Power Plant Engineering, L. H. Burkhart has an interesting article under the heading "Welding Aids Builders of Ammonia Equipment." While it is true that welding is being employed more and more and is useful and valuable, still I believe it wise not to plunge into electric or gas welding too hastily. As long as ammonia containers are not large, it is generally all right for skillful welders to weld them, but it has been observed that the manufacturers who make welding and cutting gases do not use welded containers for these gases; they use seamless drawn tubing. Whether or not safety is the reason is not stated. Possibly it is because seamless tubing is obtainable in the smaller sizes.

I believe I am right in stating that welding was first applied to ammonia equipment in connection with the so-called intermittent system of refrigeration 15 or more years ago. The receivers and generators for that system were both electrically welded. A few years later gas welding was employed as well. Some of the earlier installations of this system exploded and in one instance five people were killed. In that instance the explosion probably would have occurred anyway, as the butcher who operated this system removed the safety valve because it leaked and installed a plug in its place. It is said that during the period of generation he was busy waiting on customers and was not watching the pressure gage. The entire building was leveled to the ground.

Later on, in spite of the explosion, the company began manufacturing generators as large as 42 in. in diameter and 16 ft. long. In one installation three generators of this size were placed side by side, and two receivers each 20 in. in diameter by 20 ft. long were placed above the generators. Figure 1 shows the three generators operated. They were called A, B and C. Thus, in order to maintain a fairly constant pressure, the generators are operated in rotation; first A, then B and then C. It will be observed

that in this test, which was made nearly five years ago, the pressure did not at any time reach 175 lb. per sq. in. The pressure is dependent upon the temperature and, as will be noted, during that same cycle the temperature reached 270 deg. F.

So far as I know, no trouble has ever been experienced with the receivers in this system of refrigeration. This is

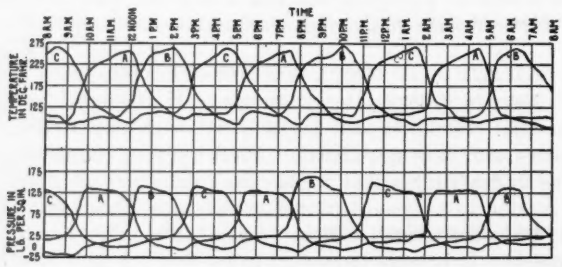


FIG. 1. DIAGRAM SHOWS HOW THREE GENERATORS OPERATE IN INTERMITTENT SYSTEM

probably because the receivers are always comparatively small and are subjected to an almost constant pressure and temperature, whereas the generators, as indicated in the graph, vary in pressure from 155 lb. to almost a perfect vacuum, and at the same time temperature varies from 270 deg. to 75 deg. F.

An action of this sort is obviously difficult for any pressure vessel to withstand, whether it is riveted or welded, and it seems to me that regardless of the advances that have been made in welding, the utmost caution should

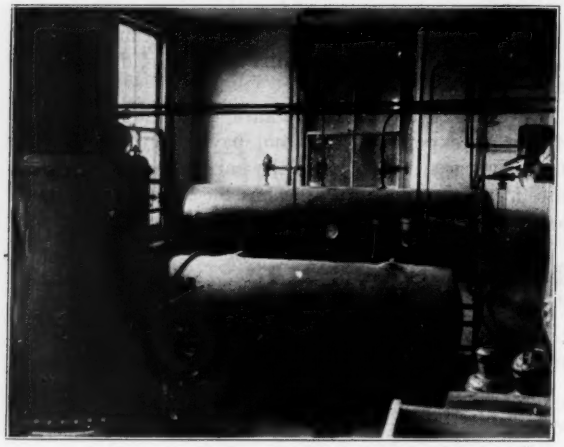


FIG. 2. VERTICAL BOILER AT LEFT SUPPLIES STEAM TO GENERATOR OF INTERMITTENT SYSTEM IN A CREAMERY

be exercised before welding is employed alone, without riveting, on pressure vessels of this type.

More Care Needed in Welding Than in Riveting

There is no question in my mind that the manufacturers of welding equipment themselves, with their skilful mechanics, can do high-grade work, equal to or even better than riveting. How can we be certain, however, that the same skillful mechanics will be employed in welding the pressure vessels that are used in hard actual practice such as the above? Inasmuch as a welded pressure vessel is no stronger than its weakest seam, it is obvious that one poor welder and four or five skilled ones will produce a job that will be no safer than that done by the poorest.

In riveting work, on the other hand, an unskilled or careless riveter, or an unskilled workman, is much less dangerous than an unskilled welder in welding. Holes that are drilled in plates are all subject to inspection before rivets are inserted. The rivets themselves can all be measured and inspected. In the final job a poorly-formed rivet head can hardly weaken a joint as much if poorly done as can poor welding.

Small openings in ammonia equipment, as mentioned by Mr. Burkhart, such as nipples, couplings and pipe bushings, I believe can be welded with perfect safety. No trouble was ever experienced with these on the above equipment. In fact, I believe that they are superior to any other type of joint. They are stronger and absolutely

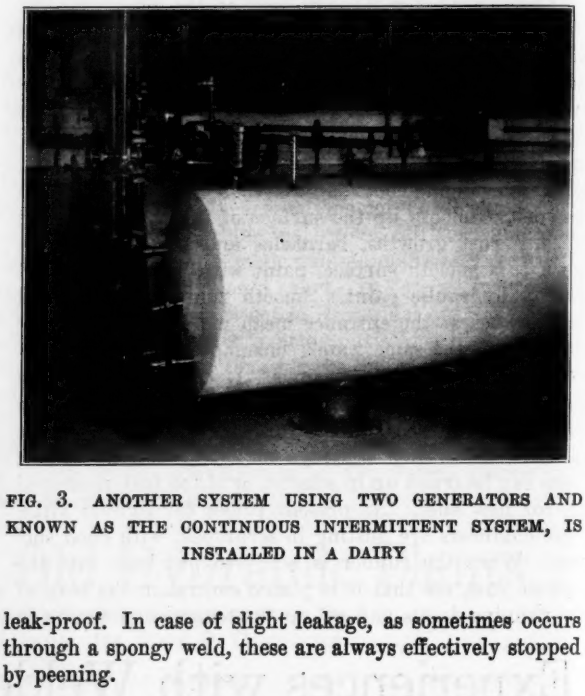


FIG. 3. ANOTHER SYSTEM USING TWO GENERATORS AND KNOWN AS THE CONTINUOUS INTERMITTENT SYSTEM, IS INSTALLED IN A DAIRY

leak-proof. In case of slight leakage, as sometimes occurs through a spongy weld, these are always effectively stopped by peening.

Construction Details of the Intermittent System

Figures 2 and 3 show some of the construction details of the intermittent refrigeration system referred to above. In Fig. 2 a vertical boiler, shown at the left, furnishes steam for a creamery and also furnishes steam for heating the generator, which is the larger horizontal tank. The ammonia receiver is the longer horizontal vessel against the wall. The welded joints at both ends are plainly in evidence. This welding was done with gas and not electrically.

In Fig. 3, two generators of larger size are shown in the foreground, both of which are covered with asbestos cement and painted white. The receiver is on the far side of the second generator and only the head end is visible. This arrangement is the "continuous intermittent" system, whereas Fig. 2 shows a single generator and is therefore a purely "intermittent" system. This system is not only dangerous when welded without riveting, but is also inefficient and uneconomical excepting under certain conditions.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Learning the Other Man's Methods

Nearly every plant engineer has maintenance duties. These are manifold but, in general, can be divided into four major classifications, thus: 1. To promote and maintain harmony among employes. 2. To stop waste in whatever form. 3. To see the need and make changes for the betterment of plant equipment. 4. To visit other plants in search of new ideas and, on occasion, to permit his foremen to do so.

Of these major duties, not the least important is the last. Engineers too frequently stay in their own plants day in and day out, months on end, never visiting a competitor's plant or going near the establishment in the next block. Too often competitors are regarded with suspicion and the act of paying a visit to a competitive plant as "spying." The factory across the street, a member of an extraneous industry, is thought to be "different."

Adherence to such erroneous beliefs perpetuates isolation, and China is an outstanding result of isolation. The problems of power generation and transmission, heating, lighting and ventilating, or machinery maintenance are much the same regardless of where found.

The maintenance engineer of a paper mill can learn much from the superintendent of a candy factory, and the superintendent of a textile mill would profit by a tour through a wood-working plant.. The writer never saw a more convenient plant, from the standpoint of operation, than a sugar refinery in Pennsylvania. Regardless of his product, any wide-awake engineer could pick up a baker's dozen of profitable ideas on a visit to that plant. The same could be said of a furniture factory in Grand Rapids. The automotive industry has done more to teach industrialists the economy of mechanical handling and the value of inter-industrial co-operation than any other single industry in all history.

Savings Accounts and What They Mean

Announcement has been made by the Savings Bank Journal that during 1925 the people of this nation saved over 24 billion dollars and that of the 112,000,000 population more than 45,000,000 maintain savings accounts. Dividing the number of depositors by the total amount of savings, we have an average of $529 for each individual account. This is the highest average in history, according to the Journal, while the total "represents a gain of approximately $1,000,000,000 over the figures for the close of business on June 30, 1925."

Such a presentation of statistics, however significant of national wealth, tells only a fraction of the story. What has this enormous total in savings done for the nation as a whole? How does the remaining 67 million people profit by the thrift of the savings-account depositors? To what use has this money been put? What real things, aside from the 3 per cent interest paid to depositors, have these credits created? Briefly, here are a few of the lasting effects created by the thrift of the 45,000,000 depositors:

Americans have three million more passenger automobiles now than one year ago. New buildings have been erected, or repairs made to old ones, in the amount of $50 per capita. $1.75 per head has been invested in the mining and metal industries. Increased public utility equipment represents $12 per head. Railroad equipment has increased to the tune of $3 per capita. Loans to foreign governments have increased $6 for every man, woman and child. Additional rubber manufacturing plants total an investment equal to 50 cents per capita, while new maritime construction represents 30 cents per head. Hospitals have increased at the rate of $2.75 per capita, while schools, during the past year, total an investment equal to $3.80 per capita. Investments in foreign corporations (including Canada) total a like sum to that of schools.

Even this recitation of disbursements and investments gives only a limited view of the true worth of savings accounts. Basically, a nation's prosperity lies not in the number of large incomes, the average earning power of the people, or in material wealth. Rather it lies in the nation's ability to banish destitution. Beautiful monuments, lovely parks, and stately buildings mean not so much to a city or a nation as the absence of slums.

Through the enterprise and thrift of the American people, made possible by our republican form of government, we have been eminently successful in this regard. Our poverty line is rapidly diminishing. Accompanying the accumulation of great wealth into comparatively few hands has been the elimination of poverty. Since 1885 the number of inmates in public charity institutions has decreased 50 per cent. In the United States, according to reliable reports, there are approximately 78,000 paupers. This is n the rato of about 7 to every 10,000 of population —as compared to 13.8 per 10,000 in 1880.

Learning to Harness Nature

Scientists tell us this earth has been in existence for several billion years—that it is but one of several planets rotating around the sun—that our little solar system is but one unit of several rotating around a common center, and that this large group of suns is one of thousands of other similar groups which again move with reference to a common center. And there are many such supergalaxies.

When we begin to talk about Nature or natural forces, we realize how niggardly was Noah Webster when he parceled out the adjectives. Old Mother Nature has been with us since the beginning yet we know her not. In our understanding of natural forces there are vast gaps. True, in our progress we have learned, here and there, how to adapt and use some natural forces, yet in comparison with our ignorance, our knowledge is infinitesimal. It is encouraging, however, to find that little by little we are learning to appreciate Mother Nature.

Not the least important development, in this regard, is the recent discovery of a method for utilizing the natural power of evaporation. We find great pleasure in talking about our enormous power plants and electrical stations, —our Muscle Shoals, our Niagara Falls, our Roosevelt Dam. Yet if we had on this continent a million more such projects, the energy we could generate therefrom would not amount to a snap of the fingers in comparison with the amount of energy Nature expends every day in

sucking up millions of gallons of water by the simple process of evaporation. And unlike man-made appliances, which operate more or less intermittently, or for only brief periods of time, the natural work of evaporation is ceaseless. It was in observing this ceaseless work of Nature that a group of engineers hit upon the idea of utilizing and employing this great natural force.

By careful survey it was found that the topographical depression in which the Dead Sea lies (1300 ft. below sea-level) is sufficiently large to permit twice the flow of the River Jordan and yet be cared for by evaporation. At present, all the water from the River Jordan is sucked up by the sun. But this natural sub-sea basin is large enough to permit an equal volume of water to that of the River Jordan to be poured into the Dead Sea and yet be absorbed by evaporation. So these engineers are now promoting a project to syphon that amount of water from the Mediterranean Sea and pour it into the Dead Sea—after it had been diverted through large turbines and made to generate 600,000 hp. of electricity.

This project, together with the one for generating electrical power by means of the tides at the Bay of Fundy, the generation of electricity from the wind, by means of windmills, the concentration of the sun's rays to generate heat and develop steam, the use of light to control positively the growth and blossoming of plants and to compel hens to lay more than one egg a day and the scheme for extracting bromide from sea water, all of which have definitely passed the embryonic stage, are encouraging signs that we are at least getting on speaking terms with Old Mother Nature.

All this would seem chimerical were it not actual, existing facts. We have need for the realization that far-reaching developments are more frequent occurrences today than 100 yr. ago. We have the momentum of the first quarter of this century to aid us in our progress through the second quarter. And momentum is not only material but mental. When we were ten years old, we didn't know a thing about automobiles. The boys that are ten now, not only know about automobiles, but about radio and aircraft as well.

One of the principal reasons why we cannot successfully visualize the future is because we are blinded by time. 1950 seems to us vague and distant, yet 1900 seems as only yesterday. They are equi-distant. Then, too, we do not accept readily that which disrupts or changes our accustomed channels of thought.

It is almost impossible for human intelligence to visualize the developments that lie immediately ahead. And that is all the more serious since vision is now as much a pre-requisite to good management as modern machines are to economic production. In the last 20 yr. many concerns have been forced out of business because they refused to modernize their plants. In the ensuing 20 yr. whole industries will cease to exist unless methods, now called visionary, are employed. There are 50,000 manufacturers in the United States that will go out of business unless they can get wood permanently and in abundance. Reforestration is already late in starting. What price wood, in twenty years?

The exercise of foresight, the quick adoption of new developments, the constant change to anything that is better, has become a first principle in business.

In a boiler plant recently visited the CO_2 recorder was seen to be out of commission. The engineer stated that it was not put in repair because "the thing never worked right because it leaked." The "secret of success" with almost any recording instrument lies in the pipe lines. These must be absolutely tight at all times. A frequent and liberal application of shellac at joints will cure many of the recorder ills. All instruments should be given a superficial inspection daily and a thorough examination once a week. This done properly, they will return splendid dividends on the investments.

That Metric System

If anyone should tell you that all the millions of school books that are now being used by every student in the country would have to be either scrapped or revised—that every mile post and every railroad time table would have to be changed—that all the jigs, patterns, gages and screw dies used by every manufacturer in the United States would have to be replaced—that every one of the grocers and retail merchants in the country would have to buy new scales and completely change his entire system of sales—that every gas and water meter would have to be recalibrated—that every publisher and every writer would talk and write in a strange language, starting tomorrow—you would say that the one doing the talking was stating an economic impossibility.

But we stand more than a fair chance of being compelled to do all these things, for Congress will soon have up for consideration the Britten Bill which provides for the universal adoption of the metric system of measurements and weights. We say "more than a fair chance" because the majority of the members of Congress are pro-metric, and the Committee on Coinages, Weights and Measurements has already favorably reported this bill to the House of Representatives.

For years the metric system has been legal in the United States but it has gained only a small measure of adoption in commercial practice. The metric system is, theoretically, more simple than our present system, which explains perhaps why non-technical editors and many theorists are in favor of it. To industrialists and engineers who appreciate the cost of a change, the movement for compulsory metric adoption is absurd, fantastic, unthinkable. But, as usual, the industrialist and the engineer have been so absorbed in the immediate problems of production that they have allowed the other side to do all the talking. And this inattention by the parties most deeply concerned has permitted pro-metric talk and effort to crystallize into action, with the result that we now stand on the threshold of a federal adoption that would be more far-reaching in effect than a law compelling every written word to be translated into the Spanish language before being published.

If anyone believes that this is a false alarm—if any reader thinks there is no likelihood of Congress making such a fool of itself as to adopt the Britten Bill making the metric system compulsory—let him write his Washington agent and put the single question: "What are the chances for the passage of the Britten Bill?" The reply will doubtless startle you, and force home the realization that prompt, concerted and vigorous action to forestall the events outlined in the first paragraph is imperative.

Superheaters Should Give Uniform Temperature

IN THE March 15 issue, p. 389, J. B. Stanwood gives an interesting description of a superheater for return tubular boilers but it seems obvious that to ascribe to this superheater, results which may be expected from all superheaters is far from giving the proposition of superheating a square deal.

We may safely assume that no one will dispute the statement that uniformity is one of the greatest contributing factors toward obtaining the highest efficiency in power house operation. If, for example, the equipment in a plant is such that steam at 500 deg. F. is a safe limit, then the temperature should be kept at that point or nearly so and a correctly designed superheater can do it. This may be proved by reference to Figs. 1 and 2, showing recording charts for steam flow and temperature respectively.

These were taken from a 516-hp. Edge Moor water tube boiler, cross-baffled and equipped with a Foster

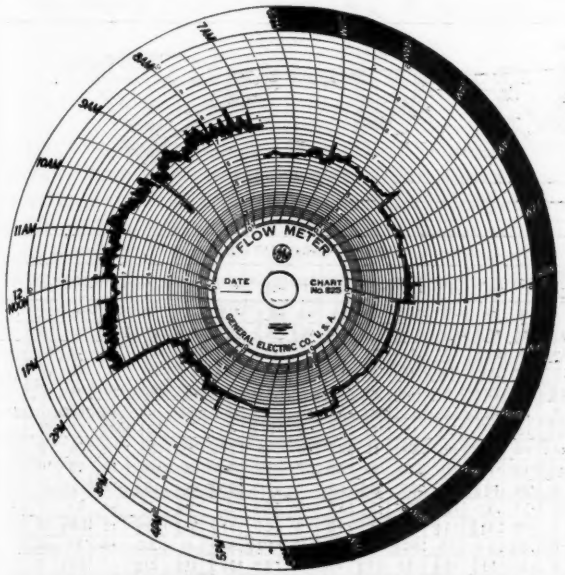


FIG. 1. THIS SHOWS THE FLUCTUATIONS IN LOAD ON A 516-HP. WATER TUBE BOILER

superheater which is installed in the usual manner between first and second pass. I realize that the conditions encountered in a return tubular boiler are somewhat different from those existing in a water-tube boiler but I am unable to find anything in Mr. Stanwood's article which would lead me to think that when he was discussing the advantages and disadvantages of superheated steam in a general way, he intended it to apply to return tubular boilers only. Should such be the case, however, I can see no reason why a correctly designed superheater installed in a return tubular boiler should not be able to keep the temperature of the steam far

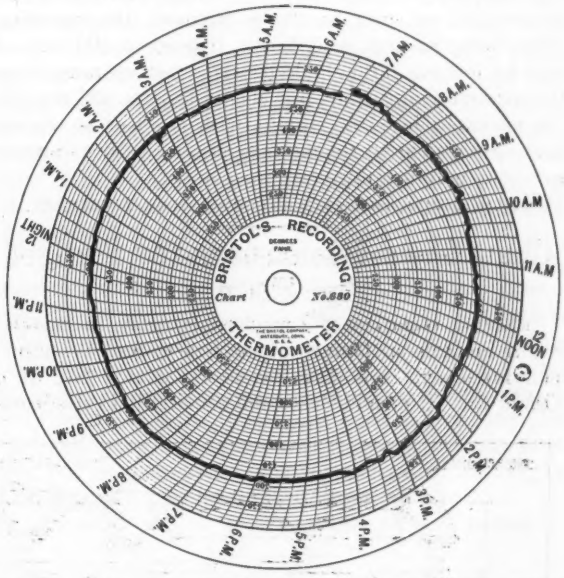


FIG. 2. WITH A PROPERLY DESIGNED SUPERHEATER, STEAM TEMPERATURE WILL BE AS UNIFORM AS SHOWN BY THIS CHART, EVEN IF THE LOAD IS AS VARIABLE AS IN FIG. 1

more uniform than the superheater described by Mr. Stanwood. It may be seen from the flowmeter chart that the load on the boiler was comparatively heavy for about 7 hr., being about 130 per cent of rating while during the remaining 17 hr. it was about 80 per cent, yet the temperature of the steam remained practically constant as shown by the chart.

A correctly designed superheater provides a relatively short path through which the steam travels at a high velocity in such a way that all the steam comes in close contact with the wall of the tube. This is accomplished by inserting a core in the tube, providing a thin annular space for the steam. Consequently, when the load on the boiler is increased and the volume of the gases and their temperature increase, the velocity of the steam through the superheater also increases and the final temperature remains practically the same.

I am of the opinion that Mr. Stanwood's superheater does not come up to this performance for the reason that when the boiler is under a small load the steam flows through the superheater at a low velocity and in a relative quiet state. Therefore, much of it

does not come in close proximity to the hot wall of the tubes, but when the load on the boiler is increased the velocity of the steam through the superheater is increased, causing its turbulence to become more pronounced. Thus a greater proportion of it comes into close contact with the wall of the tubes and the final temperature of the steam goes up. Also, I may say that to by-pass part of the steam is bad practice.

In regard to the proper steam temperature for Corliss engines, I wish to relate my own experience in this connection. When our plant was started about 20 yr. ago, we had two 400-hp. Stirling boilers equipped with superheaters, which were installed above the fire arch. With steam at 150 lb. gage pressure, they were supposed to raise the temperature 100 deg. F., which would make the total temperature 466 deg. F. But at that time the superheating of steam was in its infancy and the superheaters did not give results as planned, the superheat often being as high as 150 deg. instead of 100 deg. I find by looking through the records that on many days the average temperature for the 24 hr. was 520 deg. F., yet we experienced no trouble with our Corliss engines due, to some extent, to the fact that we used a superior grade of cylinder oil.

East Chicago, Ind. CHAS. L. ANDERSEN.

Chart Gives Dimensions for Flanged Pipe Fittings

HAVING experienced considerable delay in calculating the lengths of flanged pipes, I developed the accompanying chart from data found in catalog No. 51 of Crane Co. It should be extremely useful to draftsmen and power plant engineers, for it saves many references to a pipe-fitting catalog.

By referring to the example at the bottom for obtaining face to face measurement of pipe and the actual length of the pipe, it may be seen that the work has been materially simplified.

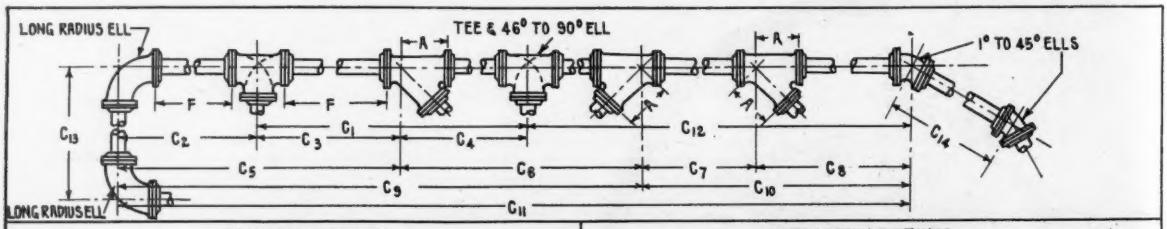
Hagerstown, Md. P. H. BYER.

Diesel Engines Raise Small Plant Efficiency

IN THE March 15 issue, p. 369, R. C. Demary shows that the fuel, labor and maintenance cost of a Diesel plant are only a little more than one-fourth that of a steam plant. While this is comparing an old steam plant with a new Diesel plant, the ratio is not far from correct for what may be called the operating cost.

There is, however, another side of power cost which is completely overlooked, namely, the fixed charges on the cost of installation. Mr. Demary does not state the size of the engines and generators in this plant but, as it operates on a 24-hr. basis, the average load is about 157 kw-hr. which would indicate that there were two units of at least 200 kw-hr. capacity.

Diesel engine-driven generators of this size will cost at least $200 per kilowatt hour installed ready to run. Even if it is assumed they could have been installed in an existing building, the installation cost of this job must have been at least $80,000. Fixed charges cannot be figured at less than 15 per cent per annum on this type of equipment, so the fixed charges for the ten months period will be at least $10,000, and, if this is



STANDARD FITTINGS

PIPE SIZE	C_1-F	C_2-F	C_3-F	C_4-F	C_5-F	C_6-F	C_7-F	C_8-F	C_9-F	C_{10}-F	C_{11}-F	C_{12}-F	C_{13}-F	C_{14}-F	X
1	7	8 1/2	5 1/2	9 1/2	6 1/2	11 1/2	3 1/2	7 1/2	10 1/2	3 1/2	6 1/2	5 1/2	10	3 1/2	1/2
1 1/4	7 1/2	9 1/2	5 1/2	10	7 1/2	12 1/2	3 1/2	8 1/2	11 1/2	3 1/2	7 1/2	5 1/2	11	4	1/2
1 1/2	8	10	6	11	8	14	4	9 1/2	13	4 1/2	8 1/2	6 1/2	12	4 1/2	1/2
2	9	11	7	12 1/2	9	16	5	10 1/2	14 1/2	5	9	7	13	5	1/2
2 1/2	10	12	7 1/2	14 1/2	9 1/2	19	5	12 1/2	16 1/2	5 1/2	10	8	14	6	1/2
3	11	13 1/2	8 1/2	15 1/2	10 1/2	20	6	13	17 1/2	6	10 1/2	8 1/2	15 1/2	6	1/2
3 1/2	12	14 1/2	9	17 1/2	11 1/2	23	6	15	20	6 1/2	12	9 1/2	17	7	1/2
4	13	15 1/2	9 1/2	18 1/2	12	24	6	16	21	7	13	10 1/2	18	8	1/2
4 1/2	14	16 1/2	10	19 1/2	12 1/2	25	6	16 1/2	22	7	13 1/2	11	19	8	1/2
5	15	17 1/2	11	21	13 1/2	27	7	18	23 1/2	8	14 1/2	12	20 1/2	9	1/2
6	16	19 1/2	11 1/2	22 1/2	15	29	7	19 1/2	26	8 1/2	16 1/2	13	23	10	1/2
7	17	21 1/2	12 1/2	25	16 1/2	33	8	22	29 1/2	9 1/2	18 1/2	14	25 1/2	11	1/2
8	18	23	13 1/2	26 1/2	18 1/2	35	9	23	31 1/2	10	19 1/2	14 1/2	28	11	1/2
9	20	25 1/2	14 1/2	29 1/2	19 1/2	39	9	25 1/2	34 1/2	10 1/2	21 1/2	16	30 1/2	12	1/2
10	22	27 1/2	16	31 1/2	21 1/2	41	10	27	37	11 1/2	23	17 1/2	33	13	1/2
12	24	31	17 1/2	36 1/2	24 1/2	49	11	32	43 1/2	13	26 1/2	19 1/2	38	15	5/8
14	26	35 1/2	20	41	27 1/2	54	12	34 1/2	48 1/2	13 1/2	29	21 1/2	43	15	
15	29	37 1/2	20 1/2	43	28 1/2	57	12	36 1/2	51 1/2	14	30 1/2	22 1/2	45 1/2	16	
16	30	39	21 1/2	45	30 1/2	60	13	38	54	14 1/2	32	23	48	16	
18	33	43	23 1/2	48 1/2	33 1/2	64	14	40 1/2	58 1/2	15 1/2	35	25	53	17	
20	36	47	26	53	37	70	16	44 1/2	64	17 1/2	38 1/2	27 1/2	58	15	

EXTRA HEAVY FITTINGS

PIPE SIZE	C_1-F	C_2-F	C_3-F	C_4-F	C_5-F	C_6-F	C_7-F	C_8-F	C_9-F	C_{10}-F	C_{11}-F	C_{12}-F	C_{13}-F	C_{14}-F	Y
1	8	9	6	10 1/2	7	13	4	8 1/2	11 1/2	4	7	6	10	4	7/8
1 1/4	8 1/2	9 1/2	6 1/2	11 1/2	7 1/2	14 1/2	4 1/2	9 1/2	12 1/2	4 1/2	8	6 1/2	11	5	1
1 1/2	9	10 1/2	7	13	8 1/2	17	5	11 1/2	14 1/2	5 1/2	8 1/2	7 1/2	12	5 1/2	1 1/2
2	10	11 1/2	7 1/2	14	9	18	5	12	15 1/2	5 1/2	9 1/2	8	13	6	1 1/2
2 1/2	11	12 1/2	8	16	9 1/2	21	5	14	17 1/2	6	10 1/2	9	14	7	1
3	12	13 1/2	9	17	10 1/2	22	6	14 1/2	18 1/2	6 1/2	11 1/2	9 1/2	15 1/2	7	1 1/2
3 1/2	13	15	9 1/2	19	11 1/2	25	6	16 1/2	21	7	12 1/2	10 1/2	17	8	1 1/2
4	14	16	10	20 1/2	12	27	6	18	22 1/2	7 1/2	13 1/2	11 1/2	18	9	1 1/2
4 1/2	15	17	11	22	13	29	7	19	24	8	14	12	19	9	1 1/2
5	16	18 1/2	11 1/2	23	13 1/2	30	7	20	25 1/2	8 1/2	15 1/2	13	20 1/2	10	1 1/2
6	17	20	12 1/2	26	15 1/2	35	8	23	29	9 1/2	17	14	23	11	1 1/2
7	18	21 1/2	13 1/2	28	17 1/2	38	9	25	31 1/2	10 1/2	18 1/2	15	25 1/2	12	1 1/2
8	20	24	15	30 1/2	19	41	10	26 1/2	34 1/2	11	20	16	28	12	1 1/2
9	21	25 1/2	15 1/2	33	20 1/2	45	10	29	37 1/2	11 1/2	21 1/2	17	30 1/2	13	1 1/2
10	23	28	17	35 1/2	22	48	11	31	40 1/2	12 1/2	23 1/2	18 1/2	33	14	1 1/2
12	26	32	19	40 1/2	25	55	12	35 1/2	46 1/2	14	27	21	38	16	1 1/2
14	30	36 1/2	21 1/2	46	28	62	13	39 1/2	52 1/2	15	30	23 1/2	43	17	
15	31	38 1/2	22	48 1/2	29 1/2	66	13	42	55 1/2	15 1/2	31 1/2	24 1/2	45 1/2	18	
16	33	40 1/2	24	51	31 1/2	69	15	44	58 1/2	17	33 1/2	26	48	19	
18	36	44 1/2	26	55 1/2	34 1/2	75	16	47 1/2	64	18	36 1/2	28	53	20	
20	39	48 1/2	28	60	37 1/2	81	17	51	69 1/2	19	39 1/2	30	58	21	

C_1, C_2, C_3 ETC. = CENTER TO CENTER DISTANCE OF FITTINGS
F = FACE TO FACE OF FLANGES
L = LENGTH OF PIPE

F = C-(C_N-F)
L = F-X (FOR STD. FITTINGS)
L = F-Y (FOR EXTRA HEAVY FITTINGS)

EXAMPLE
C_{11} = 49 1/2" FOR 8" STD. FITTINGS
F = 49 1/2" - 19 1/2" = 30" FACE TO FACE FLANGES
L = 30" - 3/8" = 29 5/8" LENGTH OF PIPE

WHEN CUTTING PIPE FOR FLANGED FITTINGS THE LENGTH MAY BE READILY DETERMINED BY THIS CHART

divided by the 1,132,000 kw-hr. generated, it will equal 0.88c per kw-hr., making the total cost per kw-hr. 2.14c.

This is, of course, considerably less than the cost of generating by steam but suppose, instead of the daily 24-hr. load, the plant had been run 55 hr. per week as is the case in many industrial plants, then the $10,000 fixed charges would have been divided by only 370,595 kw-hr. and the cost per kw-hr. would have been 2.96c which, added to the operating cost of 1.26c, makes a total of 4.22c per kw-hr.

Now, it also should be remembered that in most industrial plants boilers will have to be kept running during the heating season whether they are used to generate power or not and that many plants require steam for process work all the year round. Exhaust steam from a steam-driven generator usually can be used for these purposes. Where all or a large part of the steam exhausted by a steam-driven generator can be used, it will be found that the cost of fuel chargeable to power is even less than in a Diesel engine.

It, therefore, becomes evident that while the Diesel engine-driven generator has a much higher thermal efficiency, it is questionable whether the total cost of plant operation will be reduced by its installation. Each plant becomes a separate problem which should be investigated on its own merits before any installation of equipment is made.

A large field for the Diesel engine surely exists in pumping stations, small central stations and industrial plants where little, if any, heating is required but a careful study should be made before deciding to install it where a heating plant also must be installed.

New Haven, Conn. WM. W. GAYLORD.

Getting at the Cause of Our Educational Troubles

YOUR EDITORIAL of March 1, entitled "Getting at the Cause of Our Educational Troubles," furnishes a most interesting criticism of existing conditions and what you say undoubtedly is true. At the same time, I am not at all sure that in all or even a majority of cases the ability of a man to make the accepted college grades is an entirely reliable measure of his potential value to the engineering industry.

In discussions of this sort, the assumption almost always is made that a man's value is, of necessity, dependent chiefly upon his knowledge of the science of engineering or, perhaps I should say, upon his ability to absorb a conventional assortment of scientific knowledge, which the educational powers-that-be have decided embraces all that is necessary to salvation.

Now I have no quarrel with the selection of conventional college subjects; perhaps they provide as good a preliminary training for an engineer as reasonably could be devised for general purposes. But a connection with the industry, covering more years than I care to admit in public, has convinced me that, aside from draftsmen who are often not classed as engineers at all, and those engaged in development and research work, who generally are woefully underpaid, with, of course, a few brilliant exceptions, the majority of engineers who are really getting on in the world are engaged in work which requires a minimum of pure engineering knowledge and a maximum of other qualifications not generally considered as being of an engineering nature at all and which are in no way dependent upon a man's interest in calculus and chemistry.

It may be unfortunate that a love of pure science and the qualities required for industrial leadership are seldom found to be highly developed in the same individual but the qualities which the industry is chiefly willing to reward are executive ability, commercial sagacity and salesmanship. The man who has these qualifications but only a 70 per cent grade in college, probably will find his services in greater demand, and a better price, than the 97 per cent man who is lacking otherwise.

I am not holding a brief for the man who does not try to do his best in college or anywhere else. At the same time, it must be admitted that the ability to learn any subject is dependent to a considerable extent upon one's natural interest, and a man may be a born leader, or even a natural mechanic and inventor and still have the greatest difficulty in mastering higher mathematics or some other required subject. Yet, if we flunk him, we may spoil a first-class potential factory manager or even a great inventive genius just because he finds it impossible to conform to our conventional educational standards.

It appears to me that we should be careful not to place our arbitrary standards too high, or perhaps better still, we might keep up our standards but make them more flexible to conform to the wide range of existing industrial requirements. Thus a man who might some day make an able president of an engineering company could be encouraged to develop himself along natural lines and not be thrown into the discard because there does not appear to be any possibility of making a mathematician or a chemist of him.

Newark, N. J. JAMES O. G. GIBBONS.

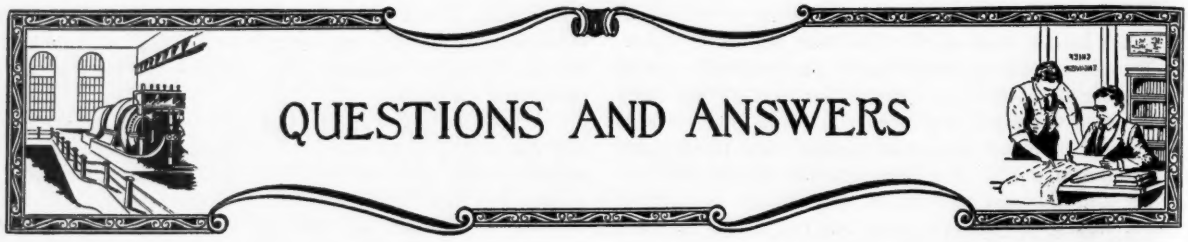
Plastic Fire Brick Holds Slipping Baffles

AT ONE time we experienced considerable loss in efficiency due to leaks in the baffles covering the bottom row of tubes in our horizontally baffled boilers. These baffles, of the type known as "C" tile, were continually slipping down, thus allowing the gases to bypass through the spaces between the rows.

To prevent this the back row was removed and a solid baffle, built of plastic fire brick, was pounded in and tied at each end to the side walls. This cured the slipping baffles and the boilers could be kept on the line 60 days instead of having to let them down in 30 days to push up the baffles. Several other remedies had been tried before without much success.

Vermillion, S. D. L. A. COWLES.

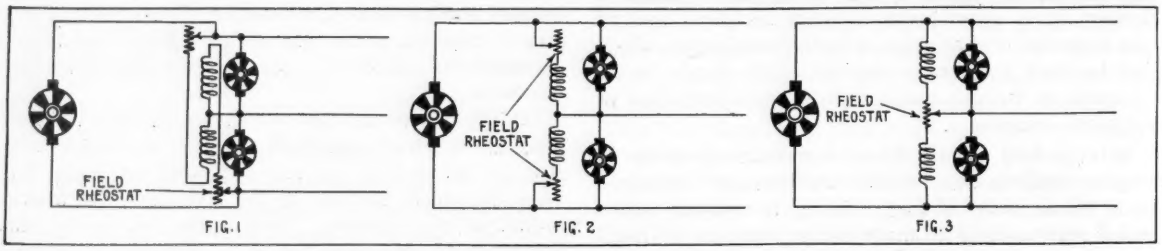
TURBO-GENERATORS for the central station at Rummelsburg at Berlin will each have a capacity of 100,000 kv.a. according to the V D I Nachrichten. Improvements in turbine design make the heat economy of these units about ¼ greater than that of the largest European single-cylinder steam turbines of 50,000 k.w. capacity. The units will have four cylinders: a high pressure, a medium pressure, and two low pressures.



Effect of Field Rheostat in Balancer Sets

REGARDING the operation of a balancer set for lighting purposes, voltage 250/125, what is the duty of the field rheostat? When should its position be changed? What will be the effect upon the balancer set of rotating the rhesotat from one position to another, assuming proper installation? S. L. M.

A. While the field rheostat on a balancer set serves the same purpose as on an ordinary d.c. motor or generator, it also serves to effect a balance between the two machines. Particularly in the case of compound balancer sets, the two machines must be exactly alike, that is, the electric and magnetic characteristics of one machine must be an exact duplicate of the other. The field rheostat makes it possible to establish this balance to a fine degree. Of course the actual effect of manipulating the field rheostat is dependent upon the manner in which the fields are connected.



THREE METHODS OF CONNECTING THE FIELD RHEOSTAT IN BALANCER SETS

In Fig. 1, for instance, the field winding of one machine is connected across the armature of the other. In Fig. 2, the fields of each machine are connected across their respective armatures with a rheostat in series with each. In Fig. 3, the fields are connected the same as in Fig. 2 but only one field rheostat is used.

Figure 2 is a little more flexible than Fig. 3, since the excitation of either machine may be adjusted independently of the other.

From these diagrams it will be seen that the actual effect of manipulating the rheostats depends upon how they are connected. In Fig. 3, for instance, assuming that the machines were balanced at no load, shifting the rheostat lever from its middle point would decrease the current through one of the fields and increase it through the other. In Fig. 2, the adjustment of either of the two rheostats will increase or decrease the excitation only of the machine in whose circuit the rheostat is connected.

The position of the field rheostat on a balancer set should be changed when it is found that the voltage of the two branches of the three-wire circuit is unbalanced, either at no load or under conditions of varying load.

Refrigeration Requirements for Ice Cream

WHAT SIZE of brine tank and coil will be needed for a 60-gal. ice-cream freezer with the mixture put into the freezer at 40 deg. F. and taken out at 26 deg. F? The ice-cream mix weighs 9 lb. per gal.

We run our ammonia compressor at 5 to 8 lb. suction pressure and the specific gravity of the brine is 1.2. It is to be kept at zero. S. C. A.

A. This problem was submitted to H. J. Macintire, Associate Professor of Refrigeration at the University of Illinois. His solution is as follows:

"The average amount of refrigeration per pound of ice cream cooled from 40 deg. F. to 26 deg. F. is 42 B.t.u., and if cooled down to 0 deg. F. in the sharp freezer, an additional refrigeration of 88 B.t.u. per pound of mix will be required, according to H. F. Zoller, American Society of Refrigerating Engineers, 1924. This idea is somewhat different from those held previously when it was considered that the freezing action in the freezer took place at constant temperature similar to that in ice-making. The new idea is that as freezing progresses, the mix gets harder and harder until at about 0 deg. F. the water content is entirely frozen. During the freezing process, beginning at a temperature of 31 deg. F. and continuing to 28 deg. F. the *swell* or *overrun* develops, which may be 70 or 100 per cent. The weight of a gallon of ice cream, therefore, depends on the care in securing a large overrun, but if the weight of the mix is 9 lb. per gal and if 50 per cent overrun is taken, the weight becomes 6.0 lb. per gal. The refrigeration in the freezer will be, for 60 gal. per hour,

$$\frac{60 \times 6.0 \times 42}{12{,}000} = 1.26 \text{ t.}$$

and in the sharp freezer

$$\frac{60 \times 6.0 \times 88}{12{,}000} = 2.64 \text{ t.}$$

"It will be noted from the preceding that there is no real similarity in ice-cream making to ice-making. In

ice-making the freezing takes place at 32 deg. F., and no agitation is necessary if the water is pure. In ice-cream freezing, the temperature continues to drop with refrigeration and the last water content probably is not frozen until 10 deg. F. is reached. There is a decided swell during freezing, due to the formation of air cells in the cream.

"If the paddles were not used, the ice cream would be very icy and unpalatable. The coefficient of heat transfer is greatly increased by the continued scraping off of the inside of the freezer and the value of k is probably as high as 40 to 60 B.t.u. per hour per degree F. difference of temperature.

"Ice-cream freezers may be cooled by means of brine or direct expansion of amomnia. The rate of cooling depends on the operator—some freeze a batch in 8 min. and others in 15 min. It seems to me, therefore, that your subscriber is not clear in the points he has asked you, for the brine storage tank size is determined by other factors, as the storage of refrigeration desired, and other refrigeration in the plant. Should he desire storage for an hour's run (should the compressor stop), he would need, for 5 deg. F. rise of brine temperature,

$$\frac{1.26 \times 12{,}000}{0.7 \times 75.7 \times 5.0} = 60.4 \text{ cu. ft.}$$

where 75.7 = weight of 1 cu. ft. of brine at 0 deg. F. and 1.2 specific gravity, and 0.7 is the specific heat.

"I would use a double-pipe brine cooler where a value for k of 150 can be used and, therefore, for 8 lb. suction and zero deg. brine a temperature difference of about 12 deg. F. is possible. The brine cooling surface required then is

$$\frac{1.26 \times 12{,}000 \times 1.2}{150 \times 12} = 10.1 \text{ sq. ft.}$$

or about 23 linear feet of 1¼ by 2-in. double pipe, allowing 20 per cent for losses."

Mufflers Needed for Air Intakes

REFERRING to H. W. K.'s query under the above title in the March 15 issue, it is my opinion that the trouble from a noisy air inlet which is being experienced is due to the fact that the air intake is too small for the requirements, setting up a rush of air into the intake pipe. This matter of supplying air to air compressors often is neglected with the result that the efficiency and capacity of the outfit is impaired considerably. It is commonly recommended by air compressor builders that the air intake duct be made at least double the cross sectional area of the inlet openings to the compressor, that this enlarged air intake duct be carried up as close to the compressor as possible, that if the duct is a long or tortuous one the size be made even larger than twice the inlet area.

My suggestion would be for H. W. K. to check up on the inlet areas of his two compressors, and then run his air intake pipe sufficiently large to provide twice the cross sectional area of these openings.

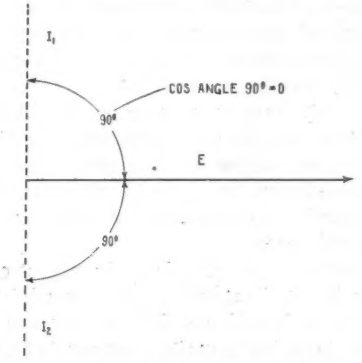
Undoubtedly the noise at the suction is caused by the high velocity of the inrushing air and the enlarged intake pipe ought to be the cure. If for any reason it is impracticable to install the larger intake pipe, the conditions might be improved by flaring the end of the intake pipe so that the acceleration of the incoming air will be gradual. If, however, the air intake is too small it is folly to put up with this inefficient condition.

M. A. S.

Leading and Lagging Power Factors

IN LOOKING over your article describing a synchronous condenser, p. 144, Jan. 15 issue, we find that we do not understand the difference between 0 per cent leading power factor and 0 per cent lagging power factor. We note, though, that these two conditions make a difference of 15,000 kw. in the capacity of the condenser. Since we are installing a synchronous condenser, we are interested in definite information. According to our knowledge, both of these designations would indicate unity power factor. S. M.

A. The power factor of an alternating-current circuit is the cosine of the angle of lag or lead between the current and electromotive force expressed in per cent.



GRAPHIC REPRESENTATION OF LEADING AND LAGGING POWER FACTORS OF ZERO PER CENT

If we refer to a table of natural trigonometric functions, we find that the angle whose cosine is zero is 90 deg. Therefore, zero power factor means that there is an angular displacement of 90 deg. between the electromotive force and the current.

If, now, we represent the electromotive force acting in a circuit by a horizontal line, E, as shown in the accompanying diagram, it will be seen that there are two positions in which we can draw a line representing the current 90 deg. removed from the electromotive force E. We can draw it either above the line as at I_1 or below the line as I_2. These two conditions represented graphically in the diagram are opposite in effect. One represents zero per cent leading power factor and the other zero per cent lagging power factor.

Assuming, as is customarily done, the vector rotation to be in a clockwise direction, the upper condition represents a lagging power factor of zero per cent and the lower line a leading power factor.

This brief explanation, we believe, should clear up any misunderstanding you may have in regard to the meaning of the two terms. Since you are about to install a synchronous condenser, however, you may be interested in two articles on the subject, one which appeared on page 959 of the September 15, 1925 issue and the other on page 1111 of the November 1, 1925 issue.

EDITORIAL COMMENT

National Programs and the Oil and Gas Power Week

Of unusual interest to the engineering fraternity, the recent Oil and Gas Power National Conference fulfilled a popular and economic demand. Backed by 28 engineering organizations, a series of 75 meetings, extending through 28 states, brought scientists, engineers and operating men together on a common ground.

Recent developments and immediate possibilities for the utilization of oil and gas for power were discussed for the purpose of broadening the field and bring results to the attention of industry or of each other.

In this age of specialization, the tendency is to overlook parallel progress in similar lines. Plainly phrased papers giving results, without masses of scientific and experimental data served to bring out the high lights of accomplishment and hold the attention of both technical and non-technical members, while the national program gave many engineers, who would otherwise have been unable to attend, for financial or business reasons, a chance to participate.

Such a national program is a big step toward reviving interest in local sections. The committee is to be congratulated on handling a delicate problem in a skillful manner, bringing together various isolated groups into a homogeneous mass and allowing hundreds of engineers to participate instead of the usual few dozen who are fortunate enough to attend the usual engineering society convention.

Standards Should Be Set by Those Who Use Them

In the development of any industry, mistakes are likely to be made which will be revealed only after time and experience have developed better ways of doing things. The king, who established the length of his foot as one standard of measurement and a certain joint in his thumb as another, made the mistake of picking out variable standards but, after they were made into rules having invariable lengths, industry for many generations has found them convenient, even though the source was not based on scientifically invariable lengths.

Other standards have been established in various countries which, without doubt, had their beginnings in just as common-place measurements as the feet and fingers of a king. So many standards have been the cause of considerable confusion and, with the growth of international commerce, there has come a need for harmony between the standards of all countries of the world. No doubt the different standards established have features which have justified their continued use, just as have the languages spoken by different nations. For this reason, standards for universal use should be the outcome of a study of all successful standards.

This is in accord with the movement for the formation of an international body to develop and perfect industrial standards which is now being discussed at the Engineering Societies Building in New York City. Some of the standards under discussion are ball bearings, screw thread systems, gaging methods, limits and fits.

In the electrical field, the International Electrotechnical Commission has for a number of years done effective work in establishing and maintaining world-wide standardization and it was with the hope that other industrial standards might be developed that the American Engineering Standards Committee called the present international conference.

What the outcome of this conference will be cannot, of course, be predicted but it has back of it the leading engineering and trade associations of the country, the members of which are most vitally interested in the standards to be discussed as they are the principal users. This method of establishing standards by common agreement on the part of the users would seem far superior to that of trying to legislate a system of standards into our industries.

The Farmer Must Do His Share

Nothing has contributed more to the success of our industrial development than the long distance transmission of electric power. In the early days before large interconnected systems had been developed, industrial enterprises could grow only at points where power was available. Electric transmission of power made it possible to supply energy at low cost to almost any community regardless of its natural power resources. This naturally lent great impetus towards the establishment of manufacturing enterprises in communities which theretofore were dependent upon activities other than manufacture for their existence, thus adding immensely to their earning possibilities.

What electricity has done for industry, it can with the farmer's cooperation also do for agriculture. One reason for the farmer's difficulties today lies in his inability, traditional or financial, to apply modern production methods to agriculture. With few exceptions, all work on the farms is done by muscular effort. There is entirely too much physical labor connected with farming for it to appeal to the type of individual who, by virtue of his intelligence, should engage in this field of endeavor. Farming, we all agree, is indispensable, yet because of its hardships and meagre financial rewards, the career of the husbandman holds little attraction for the ambitious man of today.

While the application of electricity to agriculture will do much towards liberating the farmer from his present burden of hard labor and while it will contribute greatly to the comfort and happiness of his family, it is not to be assumed that the mere extension of electric distribution lines to every farm in the country will be a

panacea for all the farmer's present troubles. Today, a large part of his difficulty in meeting the economic situation lies in his individualism and electrification will not overcome that. It has always been the aim of every farmer to be independent and, although the farmer's economic independence is largely a delusion, the prevailing belief has attracted a certain type of individual—one who, for the sake of this hypothetical independence, is content to forego the comforts and pleasures derived from cooperative society. Each farm, today, tends to be a unit, complete in itself with the owner or lessor, as the case may be, the sole manager. Until the farmers follow the example of manufacturers and consolidate their many small enterprises into large enterprises under centralized management and until they employ large scale production methods by the use of improved power-operated equipment, the agricultural industry will find itself more or less out of line in our economic scheme. The farmer has never taken full advantage of the mechanical progress that has been made during the past half century. Many labor-saving possibilities have been in existence for years but the average farmer has made little or no use of them. So, unless the farmer changes his attitude, it is to be questioned whether electrification will effect the tremendous improvement in the agricultural situation that is often claimed for it.

Electrification, however, is a step in the right direction and the power companies and other organizations who are engaged in extending service to the rural districts are to be highly commended for their foresight and courage in entering this field. To supply electric service to the rural communities of this country is a task involving the expenditure of huge sums of money and it is to be hoped that the farmers themselves will provide the cooperation necessary to make rural electrification possible.

It is for their benefit and they should be willing to assume some responsibility in the matter and to do their share of the work.

Immigrants From the Professional Classes of Europe

Since 1920, the proportion of immigrants belonging to the professional classes, which in the last few years before the war showed a tendency to decline, has increased and for the fiscal year 1924-25 was approximately three times as large as the average for 1910-14, according to an analysis of immigration statistics made by the National Industrial Conference Board. This, the Conference Board points out, reflects the economic hardships undergone during post-war years in Europe principally by those engaged in cultural activities, such as teachers, students and academicians of all kinds, scientists and engineers, artists, musicians and writers, constituting a large portion of the educated middle classes whose incomes and investments suffered severely through post-war economic adjustments.

Professional people, the Board's analysis also discloses, generally come to stay, resembling therein the agricultural immigrants and skilled workers; in contrast, the immigrants classed as common labor, to a large extent after a few years return to their home countries.

Between 1910 and 1914, out of 62,124 professional aliens who came to the United States, 50,107 or more than four-fifths remained, while from 1920 to 1925 out of 89,790 who came 73,019 or nearly four-fifths, remained. In 1923-24, the last year before the 2 per cent quota act went into effect, 24,778 professional people were admitted. The average ratio of professional immigrants to total immigration (including all men, women and children of all classes), for the years 1910-1914, inclusive, was 1.2 per cent, while in the fiscal year 1924-25 it was 3.6 per cent, or three times greater. Professional aliens during 1911-14 constituted 1.9 per cent of all male immigrants, but in 1924-25 amounted to 6.2 per cent of all male immigrants.

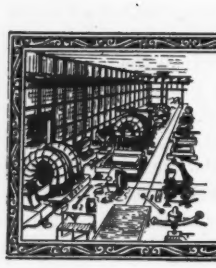
The European middle class was for a long time the backbone of the arts and sciences and its breakdown during and after the war is one of the causes of the decline of European domination in those field. Only a few years ago, in the field of pure science and applied science, the general attitude in this country was that they did things better abroad. In many cases they did. But that is not the case nowadays. The professional people of Europe, finding their whole world turned topsy-turvy—the old respect for learning gone, the incentive to engage in creative work gone, government often in the hands of dictators who are all-powerful today but may be overthrown tomorrow—these people turn instinctively to the only hope that is left, the United States. What they will find here will be determined to a great extent by what they bring. The best of them know that from now on this country is for a long period destined for world leadership. They will find here an opportunity to contribute their old world culture to our young and vigorous civilization and to have a share in that leadership.

Why Be Buried by the Progress of Others?

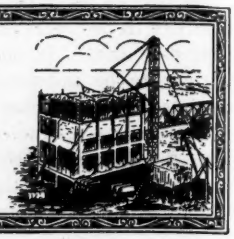
Constructive development is the result of individual thought and effort. The pioneer who cut trees to build his crude bridge was confronted with a problem requiring initiative. The son, applying his own ideas to the father's experience, was able to improve on building methods and design. Gradually specialization grew up and men by devoting their entire time to a specific problem advanced the art to a point undreamed of a few decades ago.

In each field of engineering a few outstanding figures hold the center of the stage, directing operations from a point of vantage gained and held by some trait of character or ability. Progress and achievement of these men is recorded by engineering periodicals and societies delivering a flood of information to the masses of subordinate engineers. The majority of these are busy carrying the individual ideas of the leaders or trying to assimilate all of the material at hand with the result that individual effort is in danger of being suppressed.

To take another's work and apply it to certain conditions is an easy matter but not conducive to progress. To cover thoroughly, progress in certain lines is a necessity, but to follow it so closely that no time is left for independent thought is a serious error. Outstanding leaders reached their position not by subordinating their ideas to others but by building their own ideas up from a foundation of past attainment, using carefully selected contemporary development as support.

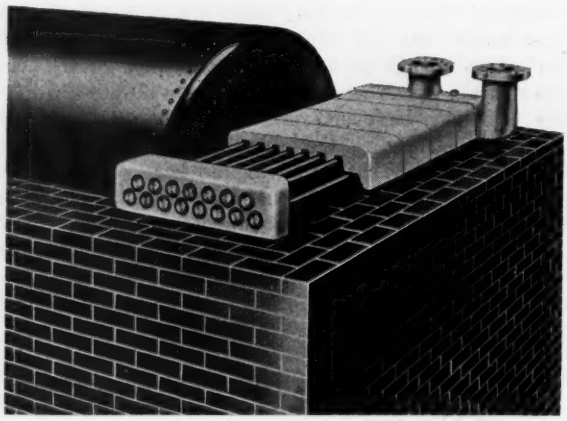


POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Superheater for H.R.T. Boilers Eliminates Rear Arch

FOR USE in connection with boilers of the horizontal return tubular type, The Power Plant Equipment Co., of Kansas City, Mo., has designed and developed the Marley steam superheater. Due to its construction, it is easily installed in any existing plant, even though there are several boilers in one battery setting. This unit can be applied to boilers using any fuel; whether oil, gas or coal.



THIS IS A NEW DESIGN OF SUPERHEATER FOR H. R. T. BOILERS. THE CAST-IRON COVER PLATES TAKE THE PLACE OF A REAR ARCH

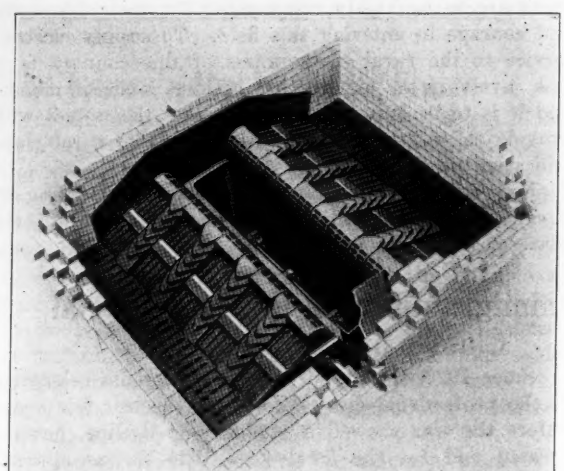
In the Marley steam superheater the heating surface is above and out of the high temperatures prevailing in the furnace, itself. There are no return bends or castings of any kind in the furnace or high temperature zone, all castings being entirely removed from this area and being supported on boiler side walls. The superheater is easily drained by means of conveniently located pipe plugs.

This superheater is made with special consideration of all mechanical features. The header manifolds are cast metal tested to several times the normal operating steam pressure. The tubes are straight, seamless drawn steel and provided with removable plugs at each end. These plugs are of the screw design, having an outside seat with a copper gasket to insure a tight fit. This makes the unit accessible for inspection, cleaning, rolling of tubes or even renewals, if necessary.

As shown in the accompanying figure, the superheater is furnished with cast-iron cover plates which in actual operation extend the full distance between both headers. The cover plates merely drop into place and require no bolting or special machine work and, after being properly located, the entire unit can be easily covered with fire brick and insulating material. The location of this superheater across the rear end of the boiler eliminates the necessity for a rear arch, the satisfactory installation of which always has been a problem.

Underfeed Stoker Has High and Low Pressure Air Zones

SEVERAL INTERESTING FEATURES of design are incorporated in the Hart stoker, which has recently been put on the market by the Hart Stoker, Ltd., Philadelphia, Pa. The accompanying illustration, a top view of the stoker, shows clearly some of these features.



DISTRIBUTING RAMS HAVE LARGE PUSHING SURFACE AND GRATE TUYERES ARE IN STEP FORMATION

A retort extends through the furnace front to the bridge wall and mounted on either side of this retort is a series of movable tuyeres alternating with distributing rams and grate bars in step formation. Directly under the retort is a high pressure air zone formed by partitions, the latter being topped with rocker bars to make a complete seal. Under the grate bars is the secondary air zone, which communicates with the high pressure zone through sliding wind gates forming part of the partitions.

Coal is conveyed either mechanically or by hand to a large hopper just outside the furnace front and forced into the retort by a ram, which is actuated by a piston

reciprocating in a steam cylinder. Attached to the under side of the ram is a shaft extending almost the full length of the retort; located at intervals on this shaft are auxiliary pushers to aid you in distributing the coal uniformly.

The purpose of the design is to cause the green coal, as it rises to the top of the retort, to spread over the sides and to be engaged by the grate bars and the upper faces of the distributing rams, which are given a reciprocating motion by the rocker bar, as shown. This agitation pushes the coal down the incline toward the dump plates.

Air is supplied at high pressure at the zone under the retort, above which the fuel bed is thickest. This air is forced out the tuyere heads through the mass of coal, in order to evaporate moisture and cause distillation of the hydrocarbons. Through the sliding gates in the partitions, air is admitted at greatly reduced pressure to the secondary zone under and through the grate tuyeres. Renewable V-shaped tuyeres are arranged with outlets on the side and in step formation, as shown in the illustration, directing the secondary air horizontally through the fuel bed. As a precaution against stratifying of the air currents, grate bars are made to overlap one another; this arrangement also is designed to prevent sifting.

The grate bars and distributing rams receive their motion from a rocker bar, which is in turn actuated by a cam on the ram described above. The Hart stoker is designed to meet conditions arising over a wide range of operation. Speed of stoker and fan is controlled by adjustment of the regulating valve. The movement of grate bars and distributing rams is varied by changing the angularity of the actuating cam by turning a screw and the air zones are controlled by the wind gates.

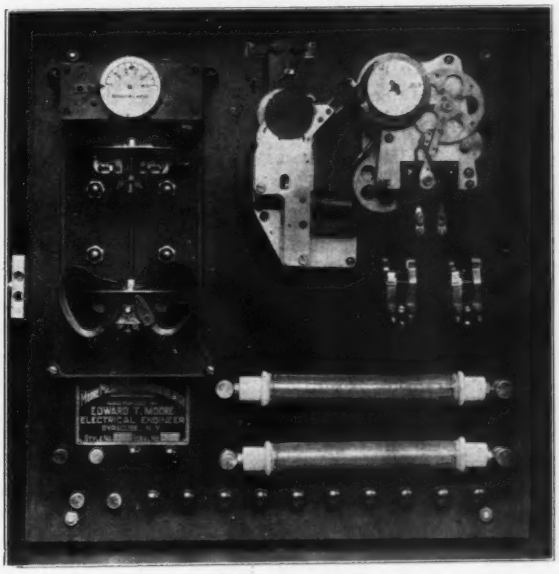
New Instrument Controls Maximum Demand

USERS OF electric power will be interested in a new piece of apparatus recently developed and placed on the market by the Pittsburgh Electric Furnace Corp. of Pittsburgh, Pa. This new device is known as the Edmoore Demand Limitator, an electrical device for automatically controlling maximum demands or peak loads on electric power systems.

As is now generally understood, central stations or other power plants must logically bill a fixed charge which is proportional to the peak or power demand to cover the cost of "readiness-to-serve" for the amount of generating machinery and the cost of the power plant is necessarily proportionate to the power demanded of the plant; that is to say, to the peak load placed upon the plant, whereas the energy charge or integrating watthour meter bill is proportional to the time or number of hours in the month during which the peak demand is used. Central stations, therefore, are vitally interested in aiding their customers and the customers are interested to a large financial extent also in limiting the power demand for peak load. The demand charge or peak load is generally rated on the highest integrated peak load averaged for one to five peaks per month, the peak generally being figured for 15, 30 or 60 min. time.

It becomes very expensive for a power consumer to draw a heavy peak for only a few minutes per month and then to continue to pay the "readiness-to-serve" charge or the demand charge for the remainder of the month. With the ordinary metering facilities at the consumers' command, it is highly desirable that the consumers should avoid drawing short time excessive peaks but, with the ordinary meter installation, it is practically out of the question for the consumer to watch and regulate the peak demanded by his load. The Edmoore Demand Limitator does this automatically.

The senior type or model 1-A Limitator, shown in the accompanying illustration, has a wattmeter element which is connected to the current and potential transformers at the main metering point of the power entrance to the consumers' premises and an electro-magnetic mechanism is embodied in the machine which is actuated periodically, depending upon the period of the



EDMOORE DEMAND LIMITATOR

demand, by a set of contacts mounted in a standard totalizing watthour meter.

Referring to the illustration, two induction elements mounted on a common shaft will be noted. The torsion on the suspending wire is varied by the rotating dial indicating the secondary watts so that any load setting may be obtained. When power in the circuit reaches the amount indicated by the dial setting movable and stationary contacts co-act, closing the lock-in relay. A load-adjusting rotating cam, mounted to engage the trip finger of the transfer switch of the integrating mechanism, closes a second relay which opens the relay of the control panel, connecting the three load adjusting resistances to be connected into the circuit of the regulator panel contact-making ammeters and reducing the power input. The auxiliary clock mechanism operates a demand period cam permitting the integrating load over any predetermined demand period to be secured.

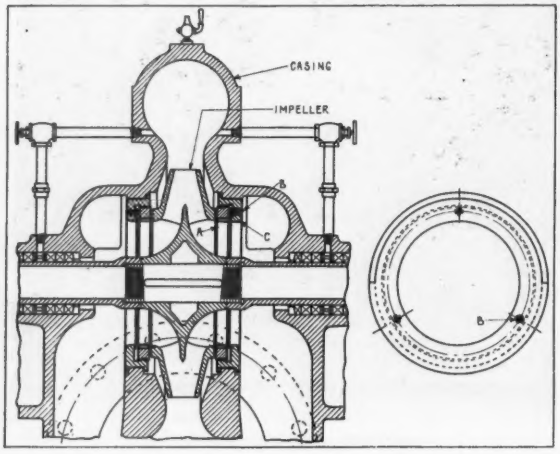
This equipment is applicable to the control of loads on electric melting furnaces as well as electric annealing furnaces, electric ovens, electrically driven compressors, pulp wood grinders, motors; in fact, for controlling any motor where the load may be reduced for a few moments

or entirely interrupted for short periods of time. It fills a dual role; it regulates the momentary fluctuations in power and limits the integrated maximum demand. The integrated element obviously would not allow large draughts of power in any period of the demand interval but, so long as the average or integrated value did not exceed the predetermined amount, there would be no reduction in load on the furnace.

The wattmeter element obviously would not allow the continuance of any momentary or short peaks as the power to the motor or other current-consuming device would be reduced instantly when the predetermined amount has been reached.

Adjustable Wearing Rings for Centrifugal Pumps

DESIGNED to maintain practically the original efficiency throughout the life of a centrifugal pump, and adaptable to any type of double suction centrifugal pump, an adjustable wearing ring known as the Adjusto-Ring, has recently been developed. Carefully conducted



SECTION OF CENTRIFUGAL PUMP EQUIPPED WITH ADJUSTO-RINGS, WHICH CONSIST OF STATIONARY RING C, ADJUSTABLE RING A AND THREE ADJUSTING SCREWS B

shop tests have shown that, while in the early stages of a pump's service no higher efficiency is obtained by using Adjusto-Rings than by using standard straight rings, this high initial efficiency can be maintained for the life of the pump with Adjusto-Rings without the need of replacing them, as is necessary with other rings that have become worn. With the standard straight ring, as well as with the labyrinth type rings, a loss of efficiency is often experienced when the pump becomes worn so that the clearance between the rotating and stationary rings becomes excessive and leakage past the rings increases. This can be corrected only by replacing the rotating ring on the impeller and the stationary ring in the case, or by truing the rotating ring on the impeller and making a new over-size stationary ring to suit. With these types of rings, there are no other means of restoring the pump to its original efficiency.

The Adjusto-Ring, developed and patented by the Frederick Iron & Steel Co., Frederick, Md., (Patent No. 1,545,608) is designed to eliminate these difficulties. With it, the original efficiency of the pump can be maintained by making an occasional simple adjustment. In its standard construction, as shown in the accompanying sketch, the Adjusto-Ring consists of a bronze case ring C, to the inner rim of which is threaded the adjustable ring A of monel metal, held in place by heavy locking screws B. In special cases, the rings will be made of other materials necessary to minimize the corrosive action of liquids to be handled by the pump. Clearance between the impeller and ring A is kept as low as possible in assembling the pump.

Adjustment is made by turning ring A on threads in C until the proper clearance is obtained, and then locking A in place. There is always a film of water between the rotating impeller and the adjustable ring but if such wear occurs that the clearance between these two parts becomes excessive, this clearance can be taken up by unlocking screws B in adjusting ring A on the threads so that it will come up close to the face of the impeller.

As an incidental advantage, this ring tends automatically to act as an hydraulic balance device, because the pressure builds up on the side of least clearance, thus giving the rotor a tendency to preserve its own balance. No claim is made for this feature, however, as it is purely incidental to the main purpose of the rings. A multi-collar thrust bearing is provided at the outboard end of the pump, which properly locates the impeller in the casing at all times. Right and left-hand screws are used, so that if the rings tend to turn they will turn away from the impeller and can do no harm.

Large Attendance Expected at the N. E. L. A. Convention

JUDGING FROM the large number of advance reservations that have been made, it is expected that the 49th annual convention of the National Electric Light Association, scheduled for the week of May 17 to 21, on the Million-Dollar Pier at Atlantic City will have an attendance of seven or eight thousand people.

The most noteworthy change in the program of this year's convention over previous years is the elimination of parallel meetings of the four national sections—the Accounting, Technical, Commercial and Public Relations, with the exception of one afternoon, Tuesday, May 18. This arrangement will provide for two additional general sessions in the afternoons during the time heretofore given over to parallel meetings. It was felt by the executive committee of the association that more good could be accomplished by each national section concentrating its particular program at one session and taking the time thus gained to interpret the work and problems of each section to the whole assembly at the extra general sessions.

An excellent exhibition of electrical equipment is to be held in conjunction with the convention. In fact this exhibition will be by far the most elaborate in the history of the association. At this writing 50 per cent more space has been reserved for exhibits than was used in 1924.

A brief tentative summary of each of the sessions outlined to date is as follows: First General Session, Tuesday morning; Address of Welcome by Mayor Bader of Atlantic City; President's address; Report of Treasurer; Report of Managing Director; Report of Public

Relations National Section; Discussion of Water Power by W. E. Creed; Report of Constitution and By-laws' Committee; Nominating Committee.

Second General Session, Wednesday morning; Report of Exhibition Committee; Report of Rate Research Committee; Report of Commercial National Section; Address by Samuel Insull; Industrial Lighting Awards; Address on Insurance in the Electrical Industry by G. H. Bourne.

Third General Session, Wednesday afternoon: Address discussing Railroad Electrification by John W. Lieb; Address by Franklin T. Griffith; Address by B. C. Forbes, and award of Forbes' Public Relations' Contest Award; Address by David Sarnoff. Other addresses to be announced later.

Fourth General Session, Thursday morning: Address by A. P. Good; Report of Prize Awards Committee; Report of Technical National Section; Address on Electric Refrigeration by G. E. Miller; Discussion of Electrification of Agriculture by G. C. Neff and E. A. White.

Fifth General Session, Thursday afternoon: Discussion of N. E. L. A. Educational Courses by Fred R. Jenkins; Address on Interchange of Energy by E. J. Fowler; Address by Gen. Guy E. Tripp; Address, Sales Organization and Management by S. D. Heed; Address by T. L. Phillips on Merchandising; Address by Alex Dow.

Sixth General Session, Friday morning: Report of Memorials Committee; Address by Bruce Barton; Electrifying the American Home, address by Mrs. Sherman; Home Lighting, address by M. Luckiesh; address by W. W. Freeman, Report of Nominating Committee; Election of Officers and Members of Executive Committee.

Engineers Discuss Plan to Maintain Great Lakes Level and Increase Power

PLANS FOR A NEW ARTIFICIAL LAKE, covering 50,000 sq. mi. and designed, first, to maintain the original level of the Great Lakes and, second, to increase the water power available in that district, were discussed recently before the Isaak Walton League of America, in Chicago, by C. Lorne Campbell, a Canadian engineer. By constructing two large dams, one on the Albany River and the other on the Ogoki River, Mr. Campbell estimated that the lake which is formed would have a watershed of more than 100,000 sq. mi. A cut from the basin southward into Lake Nipigon which empties into Lake Superior would assure the Great Lakes a minimum flow of 20,000 cu. ft. a second. It was estimated that the hydro-electric capacity of the hydro-electric plants in this district could be increased 500,000 hp. on the St. Lawrence, 350,000 hp. at Niagara, 50,000 hp. at Sault Ste. Marie, and 200,000 hp. on the Nipigon. Mr. Campbell also estimated that the saving in dredging the harbors of the Great Lakes during the next 10 years would be at least $500,000,000.

Cramp's Will Build 56,000-hp. Impulse Wheel Among Others

HYDRAULIC MACHINERY CONTRACTS for 17 units totaling nearly half a million hp. have lately been secured by the William Cramp & Sons Ship and Engine Building Co., its subsidiaries and licensees. The turbines, water wheels and other hydro-electric devices comprising these orders will be installed in Brazil, Japan, Canada and the United States. One contract calls for a 56,000-hp. impulse wheel, the highest powered of its kind in the world. Two 5000-hp. Moody propeller turbines are to be built for the Maribondo Development in Brazil and two 29,000-hp. turbines for the Nippon Electric Co. of Japan.

The 56,000-hp. impulse wheel, unrivalled in size and power in the world, will be built for the Southern California Edison Co. in the San Francisco plant of the Pelton Water Wheel Co., which is owned by the Cramp Co. Other new contracts booked by the Pelton plant include two 30,000-hp. impulse wheels for the Feather River Power Co.

The Dominion Engineering Works, Ltd., of Montreal, Canadian licensee of the Cramp Co., has secured contracts for seven hydro-electric units as follows: Three 30,000-hp. units and three 21,000-hp. units for the Canadian International Co., and one 28,000-hp. Moody propeller unit for the Manitoba Power Co.

Proposed Memorial to John Edson Sweet

AS A MEMORIAL to John Edson Sweet, founder of the American Society of Mechanical Engineers, first head of the college of engineering at Cornell University, and inventor of the straight line engine, friends of Cornell University are raising a fund to endow a professorship at Cornell to be known as the Sweet Memorial professorship.

Professor Sweet died in 1916, and it was at that time suggested that a memorial might take the form of a new mechanical laboratory. Since then the plan has been modified. It was felt that a professorship is a more enduring institution, because stone and mortar may fall to decay, while a professorship becomes an imperishable part of the institution. More than half of the fund has already been subscribed by about one hundred men, and it is thought that other persons interested in engineering education will complete the fund within a short time.

Electrical Interconnection Compared with Railroad Interchanges

ELECTRICAL INDUSTRIES OF THE COUNTRY are joining together the transmission lines of the various separately owned and separately operated electrical systems and are exchanging surplus power for the same reason that the railroads of the country have connected their tracks and for half a century have been exchanging surplus cars, Sidney Z. Mitchell, president of the Electric Bond & Share Co., told members of the New York Bond Club recently. Just as the railroads send their cars to whatever section of the country has need of them, so, through interconnected systems, the electrical companies of the country are sending surplus energy to communities that from time to time may be short of power. As each new link is forged in the chain of interconnected systems, we shall be that much nearer the super-efficiency of an industry which today supplies the United States with more electricity than is used in all the rest of the world combined.

News Notes

THE DUQUESNE LIGHT Co., Pittsburgh, Pa., is arranging an expansion and improvement program to be carried out during the remainder of the present year at a cost estimated at $18,000,000. The work will include the installation of a fourth generating unit at its Colfax power plant at Springdale, on the Allegheny River; extensions and replacements in switching equipment and other apparatus at the Brunot Island station; extensions in transmission lines in the Neville Island section, as well as at Pine Creek and vicinity; additions and improvements in substations and construction of new power substations, all in the vicinity of Pittsburgh. The company is a subsidiary of the Philadelphia Co., Pittsburgh.

THE MISSISSIPPI POWER Co., Gulfport, Miss., is arranging a construction and expansion program to be carried out over a period of months, providing upon completion, an interconnected system embracing all important districts in the state. The project will include the construction of a power dam and hydro-electric generating plant on the Tennessee River; a site has been selected near the Mississippi-Alabama state boundary, below Muscle Shoals. The station will be designed for a capacity of 200,000 hp., with steel tower transmission lines reaching a number of districts heretofore using isolated plant service. Sub-stations and distributing lines will be constructed as required. The Mississippi Power Co., of which Barney Eaton is president, is operated by the Southeastern Power & Light Co.

ANNOUNCEMENT is made that the second annual Chicago Power Show will be held in the Coliseum Building, Feb. 15 to 19, 1927, the change in location being due to the need for larger quarters as shown by applications already received for exhibit space.

Total floor space in the Coliseum is 500 by 160 ft., without pillars in booths and passageways and wide aisle space is provided to avoid congestion. Booths have been arranged with an attractive layout and a scheme of general decoration will be carried out in line with the aspirations and ideals of the power plant industry.

Location is convenient to downtown hotels. Transportation by surface lines, elevated and busses is ample and practically to the doors of the exhibit hall.

On the second floor, a meeting hall has seating for 1200 and important engineering meetings will be arranged, comparable to those held this year. The subjects covered will be of vital interest to all power-plant men.

The success of the first Chicago Power Show and of the Midwest Power Conference proved that men of this industry are vitally interested in improving the operation and efficiency of their plants and systems and argues well for an even greater success for the next year's show and conference.

C. C. FREDERICKS has become president and general manager of the St. Louis Pump & Equipment Co. He was one of the founders of the company and was responsible for its growth. Before that he was with S. F. Bowser & Co., Inc., Fort Wayne, Ind. Mr. Fredericks' first move was to engage Sherwood Hinds as chief engineer and vice-president. These two men have long been associated in the designing of liquid handling equipment.

E. P. HANNIG has recently been appointed representative of Reading Iron Company in Buffalo and vicinity.

GEO. H. FREDERICKS & Co., Milwaukee, Wis., has been appointed agent for that district for the products of Homestead Valve Manufacturing Co.

LINK-BELT Co., Chicago, Ill., announces that Nelson Brandt has rejoined its sales management force and will manage a new branch office to be opened in Florida.

ORDERS RECEIVED BY THE GENERAL ELECTRIC Co. for the first three months of the present year totaled $86,433,658, Gerard Swope, president, has announced.

WHEELER CONDENSER & ENGINEERING Co., New York City, announces the opening of a branch office in Kansas City, Mo., in the Board of Trade Bldg., under the management of Ernest H. Chapin.

MAURICE R. HART, for the last two yr. in the sales department of Morse Chain Co., has been appointed manager of the Buffalo district for that company, with an office in the Ellicott Square Bldg., Buffalo, N. Y.

AMERICAN ENGINEERING & SALES CORP. announces the opening of its offices at 1317 F St. N. W., Washington, D. C. Walter N. Polakov is president, Wallace Clark is vice president, and I. B. Richman is treasurer of the new organization.

L. J. GALBREATH, until recently engaged in advertising and sales promotion activities for the Bridgeport Brass Co., has joined the American Brown-Boveri Electric Corp. to take charge of publicity and sales promotion for that company as assistant to Earl G. Hines, recently appointed general sales manager.

PLANS ARE BEING ARRANGED for a merger of the North Penn Power Co., and the Northern Pennsylvania Power Co., under the latter name, to become effective early in April. In connection with the consolidation it is proposed to make extensions and improvements in the present power facilities and transmission system.

O. C. SHELDON, formerly located at Worcester, Mass., as advertising manager of the Riley Stoker Corp., has been transferred to the Cincinnati office of that company as district manager. C. L. Smith, formerly district manager of the Cincinnati office of the Riley Stoker Corp., has been transferred to the Chicago office as district manager.

LINCOLN ELECTRIC Co., Cleveland, O., has prepared a motion picture film, showing the use of welding in structural work based on the operations performed on a building of the Peerless Auto Sales Co., of Canton, O., the first all-welded building to be erected in the United States. Arrangements can be made by technical societies, engineering schools, chambers of commerce and similar groups to exhibit this film to their members without charge, except for express cost. Those desiring to exhibit the film should communicate with the John B. Abell Organization, 637 Union Trust Bldg., Cleveland, O.

R. M. Alvord has been appointed manager of the San Francisco office of the General Electric Co., according to an announcement by J. A. Cranston, Pacific coast manager. He succeeds E. O. Shreve, who recently was named manager of the industrial department of the company with headquarters in Schenectady.

As of April 1, 1926, the National Carbon Co., Inc., has taken over the plant, inventory and good will of the Corliss Carbon Co. J. F. Kerlin, president of the Corliss Carbon Co. and formerly assistant general sales manager of the National Carbon Co., Inc., will assume the position of vice-president of the latter, in charge of the sale of all carbon products.

Harlan A. Pratt has been appointed manager of the oil and gas engine department of the Ingersoll-Rand Co., New York. Mr. Pratt was connected for many years with the sales department of the Westinghouse Electric & Mfg. Co., later becoming sales manager of the Atlantic Elevator Co., exclusive agent in the East for Westinghouse gearless traction elevators.

The Kentucky Hydro-Electric Co. has applied to the Federal Power Commission for a preliminary permit for a power project in Cumberland River, near the mouth of Wolf Creek, in Russell County, Ky. The proposed power capacity is estimated at 54,000 kw., for public-utility purposes. The proposed dam is to be about 220 ft. high, and the pool created will have a maximum capacity sufficient to reach the tailwater level of project No. 389, Cumberland Hydro Electric Co., located on this stream.

At Fairbury, Neb., the municipal water and light plant has just been enlarged by the installation of a 1000-kw. G. E. turbine; Elliott condenser; Moore 500-hp. water tube boiler; Riley underfeed stokers driven by a Troy engine; Copes feed water regulator; Moore fan; Worthington duplex 9½ by 10 in. boiler feed pump; Cochrane hot water heater; G. E. switchboard, instruments and motors. An additional Moore 500-hp. boiler will be added at once together with stoker and accessories and another Worthington pump, 10.6 by 12 in. Installation is in charge of Supt. Fred Stutevoss.

Western United Gas & Electric Co., Aurora, Ill., operated by the Western United Corp., is arranging an expansion and improvement program to cost close to $3,000,000. The work will include the construction of an addition to the present steam-operated power plant at Aurora, with the installation of two 30,000-hp. turbo-generators, and considerable auxiliary equipment, including boilers, coal and ash-handling machinery, pumping equipment, condensers, switchboard apparatus, etc. Work will proceed on a 30,000-v. transmission line from Elgin to Glen Ellyn, recently placed in progress, as well as other transmission line construction.

The Florida Power & Light Co., Miami, Fla., has concluded negotiations for the purchase of new properties, comprising the electrical distributing system and waterworks at Coral Gables, Fla., and will consolidate with its holdings. Plans are under consideration for extensions and improvements in this district, to be carried out in connection with a general expansion program now under way. This includes the enlargement of power facilities and the construction of more than 500 miles of high tension lines. The company is a subsidiary of the American Power & Light Co., New York, under the direction of the Electric Bond & Share Co., of the last noted city.

The Fall Mountain Mills of the International Paper Co. in Bellows Falls, Vt., are to be razed this summer to make way for the construction of a 45,000-hp. unit of the New England Power Co. which recently acquired the property, with the exception of the core plant and one building housing one paper-making machine.

At Gulf Island, near Lewistown, Me., construction work is advancing rapidly on the new hydro-electric plant of the Central Maine Power Co. A concrete dam 2000 ft. long and 50 ft. high will create a new lake 12 mi. long, and the power plant will contain three generating units with a total capacity of approximately 30,000 hp. to be increased later to 50,000.

The Harlem Valley Electric Corp., Pawling (Dutchess County), N. Y., has received permission to take over and consolidate a number of electric light and power companies operating in Dutchess and Westchester Counties, including the Carmel Light & Power Co.; Chatham Electric Light, Heat & Power Co.; Lebanon Valley Lighting Co.; Morgan & Wyman Electric Light & Power Co.; Amenia Electric & Power Co.; and George Juengst & Sons, Croton Falls. It will also acquire the property of the Ridgefield Electric Co. of Connecticut at Lewisboro, Westchester County. The purchasing company is operated by the Associated Gas & Electric Co., New York.

Catalog Notes

Tangldust air filters are described in detail in an attractive 4-page folder issued by The Cooling Tower Co., Inc., 15 John St., New York. Attention is called to the 2-stage construction allowing for the separation of the heavier dirt and the finer dust, the low resistance to air flow and the provision for quick and easy cleaning. Photographs and drawings of details of these filters are given, together with discussion of specific applications of them and typical specifications.

The Ljungstrom air preheater is described in considerable detail in Bulletin A-11 just issued by The Air Preheater Corp., 25 Broadway, New York. A detailed description of the apparatus is given, showing the method of transferring heat from flue gas to air by means of a rotating element and giving details of all the parts of the equipment. This is followed by a discussion of advantages of using the Ljungstrom air preheater and the bulletin is concluded with some interesting line drawings showing typical installations of the preheater, performance curves and tables of dimensions.

The Carbondale Machine Co., Carbondale, Pa., has recently issued Bulletin No. 1125, containing data on duplex 2-stage compression refrigerating systems. The bulletin gives a discussion of the development of these systems, discusses the Worthington feather valve used on its compressors and presents many interesting illustrations of compressors both in detail and in assembly. Tables of

dimensions of the feather valve compressors made by the company are also shown. In Bulletin No. 1225, Carbondale brine coolers are described. Some information on the basis of design of these coolers is given, together with discussion of applications and many interesting illustrations of various types of coolers.

"MONO" BOILER BAFFLING IS DESCRIBED in a bulletin sent by King Refractories Co., Inc., 1707-1715 Niagara St., Buffalo, N. Y. This is a monolithic baffle and the bulletin contains diagrams of its installation on various types of boilers, as well as a diagram showing average temperatures and flue gas conditions in a 3-pass boiler.

STANDARD OIL CO. OF NEW YORK has just issued the first number of a new publication called "Oil-Power," devoted to conservation of petroleum and machinery and dealing with all the broader phases of lubrication. The first number contains articles on the importance of lubrication principles of bearings and preventing plant shutdowns.

"HOW TO ISOLATE MACHINE VIBRATIONS" is the subject of a recent bulletin issued by The Korfund Co., Inc., New York. This bulletin presents: first, a discussion of the importance of preventing machine vibration or of isolating it; second, a discussion of various types of isolating materials; and, third, details of the Korfund method, which employs cork held in specially constructed Korfund plates.

BLEEDER TURBINE protecting valves are described in Bulletin No. 8-K, issued by Schutte & Koerting Co., Philadelphia, Pa. These valves are designed for use in the extraction lines leading to feed water heaters operated with bleeder type turbines and are designed to guard the turbine against a back flow of water or of steam vapors from the heater shells. Diagrams of various heater systems show how the protecting valves are installed and various photographs and cross-sections show details of the valves themselves.

J. H. WILLIAMS & CO., BUFFALO, N. Y., has recently added to its line of drop-forged wrenches the "Superench," made of chrome-molybdenum steel. These are furnished heat treated and nickel finished and are positively guaranteed against breakage. A change has also been announced in the finish of Williams drop-forged wrenches of carbon steel. These are now supplied with smooth surface covered with black enamel baked on, bright heads and case-hardened. Booklet No. A-81 furnishes a complete list of all the Williams wrenches and may now be had on request.

IN AN ATTRACTIVE BOOKLET, No. G.E.A.—324, entitled "Electric Night by Radio," General Electric Co., Schenectady, N. Y., is publishing the addresses that were broadcast on "Electric Night," Oct. 21, from 18 broadcasting stations covering the United States. This national celebration, sponsored by General Electric Co., commemorated the 46th anniversary of the incandescent lamp and paid tribute to Thomas A. Edison.

History, progress, rural electrification, public relations, and many other subjects relating to the electrical industry are discussed. Among the 32 speakers were two members of the Cabinet, Herbert Hoover, Secretary of Commerce, and William M. Jardine, Secretary of Agriculture, in addition to officials of banks, electrical associations, central station companies and manufacturers.

RIC-WIL CAST IRON CONDUIT, for use under railroads, heavily truck-traveled highways and other places where the conduit is subject to extraordinary load, is described and illustrated in a four-page leaflet issued by the Ric-wiL Co, Cleveland, Ohio.

DODGE MFG. CORP., MISHAWAKA, IND., has recently issued a bulletin on Dodge-Timken transmission and industrial bearings. Interesting views of various steps in the manufacture of these bearings are shown; illustrations of Dodge-Timken transmission applications, shaft mountings and application to conveyors, fans and wood and metal working machinery also appear in the bulletin.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for April 1, 1926.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse side of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)
Technical Publishing Company, Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 29th day of March, 1926.

James S. Valentine.

(My commission expires September, 1926.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

"Service is Their Heritage"

Every man's life being essentially a fight against time, whether in work or play, that which aids him most in this fight is of the greatest service.

Mechanical power, already mankind's greatest time-saver, is daily becoming more and more in demand as men come into a broader realization of the fundamental service it gives to every aspect of their lives.

Because of the universal service it gives, power, probably more than any other development of civilization, is a force that is of the people, by the people and for the people.

On this basis, power men have built their great enterprises and the success that warrants the vast expansions immediately ahead.

Thousands of invisible threads of a common interest and purpose weave millions of lives into one vast interrelated organization that finances and consumes power; that invents and constructs the machines and equipment for power production, and that builds and operates power plants.

The body of people interested in power constitute the throbbing heart of industry, of business, of the Nation itself, for this is a power-built civilization and ours the country where the people benefit the most by power.

Men who invent, perfect, design, build and operate machines have ever been men with a vision of the people's good.

These are the men who have built power in the past and to whom the power developments of the future beckon with opportunities that constantly increase.

For, when service is real and the spirit back of it sincere, it commands support from even those who are incapable of seeing the vision that prompts it.

These pages serve the men charged with the upbuilding of power, that the people may be served better and more efficiently.

Through Power Plant Engineering ideas are interchanged, information passed on from mind to mind and knowledge broadened so that sound judgments may be formed.

That this means of transmission shall not fail, that misinformation shall not creep in and so be reflected in less efficient plants and ultimately in less efficient service to the people, is the inescapable responsibility of every man who contributes to its pages.

In the advertising pages, as in the editorial pages, this spirit of service prevails and a small army of men including scientists, engineers, technical writers and men trained in the visualization of ideas on paper, contribute to their production.

Laboratory experiments, shop tests and records; operation records and the history of performance in plants; the experience gained over many years and through hundreds of installations in plants of all kinds, are epitomized in advertisements you find printed herein.

Profit by the service offered. In turn, contribute to it, for plant experience is the final test of all products and the responsible manufacturers that advertise here want to know how their products serve.

A Move to a New Home

FOR eighteen of the thirty years that POWER PLANT ENGINEERING has served the field of power generation and distribution, its publication offices have been located in the Terminals Building at 537 S. Dearborn St. Modest indeed was the first suite of offices but, as staffs were augmented in each department, rooms were added until all but one room of an entire floor was occupied.

That POWER PLANT ENGINEERING has kept pace with advances in the field is evidenced by a steady and consistent increase in reader interest expressed by men in America's power plants. From one editor in 1908, the staff has grown until now six men are devoting their time exclusively to the editing of its semi-monthly issues. Seventeen times as many manufacturers of power plant equipment and supplies as in 1908 now use the advertising pages of POWER PLANT ENGINEERING to assist them in the marketing of their products.

Present offices are no longer adequate for the needs of our organization and suitable space could not be had in the building. Therefore our offices have been moved to new, larger and modernly equipped quarters on the sixth floor of the Monadnock Block, 53 West Jackson Boulevard, Chicago.

This is one of the largest and most substantial buildings in Chicago's "Loop" district, a center for a great part of the engineering activities of the Middle West. In it are found the rooms and library of the Western Society of Engineers, the offices of many manufacturers of power plant machinery and equipment, consulting engineers and Chicago offices of a large number of the country's engineering firms.

As the map shows, POWER PLANT ENGINEERING'S offices will be in the center of business activity. Within five minutes' walk are practically all the financing, engineering and operating headquarters of the public utility and industrial companies that center in the Middle West, whose activities reach from Maine to California and from Canada to the Gulf of Mexico.

More space for increased facilities and a more central location will be reflected in a still greater and more intensified service to the men who design, build and operate the country's largest power plants, and to the manufacturing firms which serve POWER PLANT ENGINEERING'S clientele of readers with their products.

Our friends are cordially invited to visit us and inspect our new home in the Monadnock Block at 53 West Jackson Boulevard, Chicago.

POWER PLANT ENGINEERING

53 West Jackson Boulevard, Chicago, Illinois